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### A METHOD AND A DEVICE FOR REDUCING HYSTERESIS OR IMPRINTING IN A MOVABLE MICRO-ELEMENT

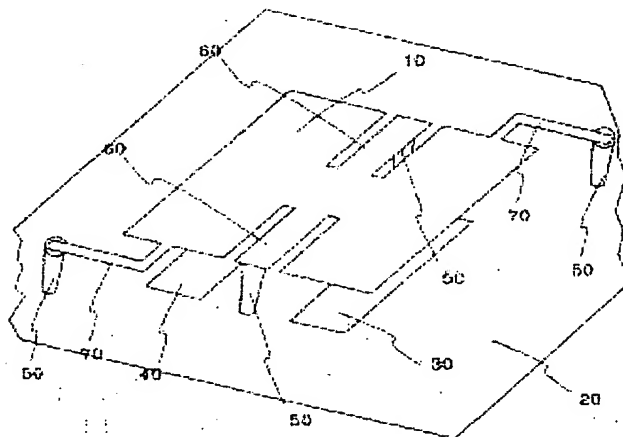
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The present invention relates to a movable micro element with reduced imprinting or hysteresis effect arranged spaced apart from a surface comprising at least one electrode. At least one restoring element is connected to said movable micro element. An address electrode is arranged on said surface and capable to electrostatically attract said movable micro element. Said address electrode is addressed to a first potential. Said movable micro element is first set to a second potential defining a non addressed state and at a time period  $[\Delta t]$  before a predetermined pulsed signal is emitted said movable micro element is switched from said second potential to a third potential defining a addressed state. Said movable micro element is kept in said addressed state for a time period of  $[\Delta t] + [\Delta t]'$ . The invention also relates to a Spatial Light Modulator (SLM), an apparatus for patterning a workpiece and a method of reducing an imprinting or hysteresis effect of a movable micro element.



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**CLAIMS**


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[Claim(s)]

[Claim 1]

Are estranged and arranged from the surface (20) which has at least one electrode, are movable microelement with little hysteresis (10), and to said movable microelement (10). In that by which at least one return component (60, 70) is connected, an address electrode (40) is allocated on said surface (20), electrostatic suction of said movable microelement (10) is possible, and the address of said address electrode (40) was carried out to the 1st potential, In time deltat before a predetermined pulse signal is first sent to said movable microelement (10) to said movable microelement (10), Movable microelement (10), wherein it is set as the 2nd potential that forms a non-address state, said movable component is changed from said 2nd potential to the 3rd potential that forms an address state and said movable microelement (10) is maintained by said address state between time delta  $t+\delta t$ .

[Claim 2]

Movable microelement (10) which is the movable microelement (10) of Claim 1, and is returned to said non-address state after said address state when said movable microelement (10) returns said 3rd potential to said 2nd potential.

[Claim 3]

Movable microelement (10) from which it is the movable microelement (10) of Claim 1, and said movable microelement (10) is changed by electrostatic \*\*\*\*\* after said 2nd potential state.

[Claim 4]

Are the movable microelement (10) of Claim 3 and said predetermined pulse signal, Movable microelement (10) which can clear said address electrode (40) and potential difference between said movable microelement (10), and returns said movable microelement (10) to said electrostatic \*\*\*\*\* by this.

[Claim 5]

Movable microelement (10) which is Claim 1 or the movable microelement (10) of 4, and is the electromagnetic radiation by which said predetermined pulse signal is turned to said movable microelement (10).

[Claim 6]

Movable microelement (10) which is Claim 1 or the movable microelement (10) of 4, and is an electrical signal with possible making discharge of a capacitor by which loading is carried out in said 1st potential start while said predetermined pulse signal is connected to said address electrode (40).

[Claim 7]

It is one movable microelement of the Claims 1-6 (10), and said time delta  $t+\delta t$  is movable microelement shorter than 10 ms (10).

[Claim 8]

It is one movable microelement of the Claims 1-6 (10), and said time delta  $t+\delta t$  is movable microelement shorter than 10 microseconds (10).

[Claim 9]

Are the movable microelement (10) of Claim 1 and a value of said 2nd potential, . In both maximum potential and minimum potential by which an address is carried out to said address electrode (40), form non-deflection status. Movable microelement (10) in which it is substantially equal to a half of maximum potential by which an address is carried out to said address electrode (40), and said 3rd potential is substantially equal to said minimum potential by which an address is carried out to said address electrode (40).

[Claim 10]

Movable microelement (10) which is one movable microelement of the Claims 1-9 (10), and is supported by a twist hinge (60) of a couple with which said movable microelement (10) forms the axis-of-torsion heart along with the omitted portion.

[Claim 11]

Are one movable microelement of the Claims 1-9 (10), and said movable microelement (10), It is supported by member rotates (65) of a couple which forms the tiltable shaft heart along with the omitted portion, and said return component, Movable microelement (10) which is at least one crookedness hinge (70) which can permit that can come, simultaneously said movable microelement (10) tilts by a circumference of said tiltable shaft heart while returning said movable microelement (10) in non-deflection status.

[Claim 12]

Are the movable microelement (10) of Claim 10, and further, while returning said movable microelement in non-deflection status, Movable microelement (10) which has at least one crookedness hinge which can permit that can come, simultaneously said movable microelement (10) tilts by a circumference of said tiltable shaft heart or said axis-of-torsion heart.

[Claim 13]

Are one movable microelement of the Claims 1-9 (10), and said movable microelement (10), While returning said movable microelement (10) to a relaxed state along with one of omitted portions, Movable microelement (10) currently supported by a crookedness hinge (70) of a couple which can permit carrying out vertical migration to said surface (20) where it can come, simultaneously said movable microelement (10) has said at least one electrode.

[Claim 14]

Are one movable microelement of the Claims 1-9 (10), and said movable microelement (10), While returning said movable microelement (10) to a relaxed state along with two of the omitted portions, Movable microelement (10) currently supported by

two pairs of crookedness hinges (70) which can permit carrying out vertical migration to said surface (20) where it can come, simultaneously said movable microelement (10) has said at least one electrode.

[Claim 15]

Movable microelement (10) by which it is the movable microelement (10) of Claim 13 or either of 14, and said crookedness hinge (70) is attached to a corner of movable microelement (10) of polygonal shape.

[Claim 16]

Movable microelement (10) by which it is the movable microelement (10) of Claim 13 or either of 14, and an account crookedness hinge of beforehand (70) is attached to a surface part of movable microelement (10) of polygonal shape.

[Claim 17]

Movable microelement (10) whose at least one of the at least one and/or said axis-of-torsion hearts of said crookedness hinge (70) it is one movable microelement of the Claims 10-16 (10), and is winding form.

[Claim 18]

Are one movable microelement of the Claims 1-17 (10), and said surface (20), Having the counterelectrode (30) estranged from said address electrode (40) to the side, said address electrode (40) and said counterelectrode (30) are the movable microelement which can attract [ electrostatic ] said movable microelement (10) (10).

[Claim 19]

Movable microelement (10) which is the movable microelement (10) of Claim 18, and said predetermined pulse signal can clear [ microelement ] potential difference between said address electrode (40) and said counterelectrode (30), and returns said movable microelement (10) to said non-address state by this.

[Claim 20]

Movable microelement (10) which is the movable microelement (10) of Claim 18, and said predetermined pulse signal can clear [ microelement ] potential difference between said address electrode (40) and said counterelectrode (30), and returns said movable microelement (10) to electrostatic \*\*\*\*\* by this.

[Claim 21]

Movable microelement (10) which is the movable microelement (10) of Claims 19-20, and is the electromagnetic radiation by which said predetermined pulse signal is turned to said movable microelement (10).

[Claim 22]

Movable microelement (10) which is the movable microelement (10) of Claims 19-20, and is an electrical signal which can discharge a capacitor by which loading is carried out in said 1st potential while said predetermined pulse signal is connected to said address electrode (40).

[Claim 23]

Movable microelement (10) to which it is Claim 1 or the movable microelement (10) of 19, and said predetermined pulse signal synchronizes with said time  $\Delta t + \Delta t'$  so that said time  $\Delta t + \Delta t'$  may become equal substantially with pulse length of said predetermined pulse signal.

[Claim 24]

A spatial-light-modulation machine, wherein it is a spatial-light-modulation machine provided with two or more reflecting members and said reflecting member is one movable microelement of the Claims 1-23 (10).

[Claim 25]

A spatial-light-modulation machine with which it is a spatial-light-modulation machine of Claim 24, and said reflecting member is set as one potential via one common element pin.

[Claim 26]

A spatial-light-modulation machine with which it is Claim 23 or a spatial-light-modulation machine of 24, and said counterelectrode (30) is set as one potential via one common opposite pin.

[Claim 27]

A spatial-light-modulation machine with which it is a spatial-light-modulation machine of Claims 23-26, and changes said all reflecting members substantially into the same time and an address state.

[Claim 28]

The following [ it is equipment for patterning a work (60) which is arranged in an image formation face and induces electromagnetic radiation ],

A source (11) which emits electromagnetic radiation towards an objective surface,

It has the computer control reticle (30) which received said electromagnetic radiation in said objective surface, and was constituted so that this electromagnetic radiation might be relayed towards said work (60) arranged in said image formation face and which has two or more reflective elements,

In that in which said computer control reticle (30) has two or more reflective elements here,

Equipment, wherein said reflective element is one movable microelement of the Claims 1-23.

[Claim 29]

In that in which it is a method for reducing hysteresis of movable microelement estranged and arranged from the surface, and said surface has at least one electrode here, said methods are the following processes. :

A process of setting said movable microelement as the 2nd potential that forms a non-address state,

It is the process of carrying out the address of the address electrode to the 1st potential, said address electrode is arranged on said surface here, and it is a process which can attract [ electrostatic ] said movable microelement,

A process changed from said 2nd potential to the 3rd potential that forms an address state in time  $\Delta t$  before said movable microelement is sent to a predetermined pulse signal,

A process of maintaining said movable microelement in said address state between time  $\Delta t + \Delta t'$

How to include.

[Claim 30]

It is the method of Claim 29 and is a process of further the following. :

How to include a process returned to said non-address state by changing said movable microelement from said 3rd potential to said 2nd potential.

[Claim 31]

It is the method of Claim 29, and also they are the following processes. :

How to include a process of changing said movable microelement after said address state at electrostatic \*\*\*\*\*.

## [Claim 32]

It is the method of Claim 31, and also they are the following processes. :

How to include a process which clears potential difference between said address electrode and said movable micro mirror, and returns said movable microelement to said electrostatic \*\*\*\*\* by this with said predetermined pulse signal.

## [Claim 33]

A way it is one method of the Claims 29-32, and said predetermined pulse signal is an electromagnetic radiation signal turned to said movable microelement.

## [Claim 34]

How to be one method of the Claims 29-32, and be an electrical signal with possible making discharge of a capacitor by which loading is carried out in said 1st potential start, while said predetermined pulse signal is connected to said address electrode.

## [Claim 35]

It is one method of the Claims 29-34, and said time delta  $t+\delta t$  is a method shorter than 10 ms.

## [Claim 36]

It is one method of the Claims 29-34, and said time delta  $t+\delta t$  is a method shorter than 10 microseconds.

## [Claim 37]

Are one method of the Claims 29-36, and a value of said 2nd potential, . In both maximum potential and minimum potential by which an address is carried out to said address electrode, form non-deflection status. A method that it is substantially equal to a half of maximum potential by which an address is carried out to said address electrode, and said 3rd potential is substantially equal to said minimum potential by which an address is carried out to said address electrode.

## [Claim 38]

It is one method of the Claims 29-37, and also they are the following processes. :

How to include a process of supporting said movable microelement along with the omitted portion with a twist hinge of a couple which forms the axis-of-torsion heart.

## [Claim 39]

It is one method of the Claims 29-37, and also they are the following processes. :

Along with the omitted portion, are a process supported by a member rotates of a couple which forms the tiltable shaft heart, and here said movable microelement said return component, How to include a process which is at least one crookedness hinge which can permit that can come, simultaneously said movable microelement tilts by a circumference of said tiltable shaft heart while returning said movable microelement in non-deflection status.

## [Claim 40]

It is one method of the Claims 38-39, and is a process of further the following. :

How to include a process to which said movable microelement is returned with at least one crookedness hinge.

## [Claim 41]

It is one method of the Claims 29-37, and is a process of further the following. :

While returning said movable microelement to a relaxed state along with one of omitted portions, said movable microelement, How to include a process supported with a crookedness hinge of a couple which can permit carrying out vertical migration to said surface where it can come, simultaneously said movable microelement has said at least one electrode.

## [Claim 42]

It is one method of the Claims 29-37, and is a process of further the following. :

While returning said movable microelement to a relaxed state along with two of the omitted portions, said movable microelement, How to include a process supported with a crookedness hinge of a couple which can permit carrying out vertical migration to said surface where it can come, simultaneously said movable microelement has said at least one electrode.

## [Claim 43]

A method by which it is one method of the Claims 41-42, and said crookedness hinge is attached to a polygonal corner.

## [Claim 44]

A method by which it is one method of the Claims 41-42, and said crookedness hinge is attached to a polygonal surface part.

## [Claim 45]

A way it is one method of the Claims 38-44, and at least one of the at least one and/or said axis-of-torsion hearts of said crookedness hinge is winding form.

## [Claim 46]

A way it is one method of the Claims 29-45, and said movable microelement is one movable microelement of the Claims 1-23.

## [Claim 47]

It is one method of the Claims 29-46, and is a process of further the following. :

How to include a process which synchronizes said predetermined pulse signal with said time delta  $t+\delta t$  so that said time  $\delta t$  may become equal substantially with pulse length of said given signal.

## [Claim 48]

It is the method of Claim 29 and is a process of further the following. :

How to include a process of neutralization-izing an accumulation history operation while preventing said pulse signal reaching said movable microelement.

## [Claim 49]

A method which is the method of Claim 48, and is performed when a neutralization chemically-modified [ said ] degree makes an opposite direction deflect movable microelement of these each to the state of deviating during an operation by which said movable microelement was meant.

## [Claim 50]

A method which is the method of Claim 49 and is deflected in given time and a given deflection degree, and the 1st direction according to a degree of a deviation [ in / in each movable microelement / said accumulated time and the 2nd deflection direction ].

## [Claim 51]

A method performed between different strips from which it is the method of Claim 48 and said neutralization-ization of said accumulation history operation constitutes a perfect pattern on a work.

## [Claim 52]

A method by which it is the method of Claim 48, and said neutralization-ization of said accumulation history operation is

performed after the accumulated time deviation of predetermined is carried out for at least one movable microelement.

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[Translation done.]

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[Field of the Invention]

[0001]

This invention relates to the technology for generally decreasing the hysteresis or hysteresis in a machine member, and movable microelement and the method of carrying out an address to it especially.

[Background of the Invention]

[0002]

The hysteresis or history of mirror deflection quantity in the spatial-light-modulation machine (SLM) used as the cause of changing address voltage required for a suitable mirror deviation is a problem in order for the accuracy of a deviation of a mirror to fall by it. The time, the deflection quantity, and the mirror by which that mirror was deflected depend for this change on the time which needs to loosen after that deviation. Since the ranges of the damping time constant of these phenomena are several minute room/several hours, required address voltage is predicted in a mask writer or the arbitrary patterns in the direct writer which uses the newest SLM technology, and it cannot compensate it as a matter of fact.

[0003]

The problem in compensating a history is on data being loaded to the mirror of SLM from the always same direction for every line. When this has all the mirrors in perfect deflection status, it means that the pixel of the 1st row has a very high duty cycle, and they have a very low duty cycle and it has a middle duty cycle in a middle line in the last line. Therefore, unless SLM is reconstructed so that data may be loaded from the 1st line and the last line for every two-times eye in order to equalize these duty cycles, as balance to hysteresis, also using collectively the pixel counter electrode in which an address is possible -- an impossibility -- or it is dramatically difficult at least. Even when constituted such, a history is still pattern dependence. Probably, it will be required to neglect predetermined time and its system to an idle state, in order to proofread a mirror frequently or to loosen the mirror of SLM.

[0004]

Therefore, little method and equipment of hysteresis are called for in the field concerned.

[Description of the Invention]

[Problem to be solved by the invention]

[0005]

In the method for carrying out an address to movable microelement and each movable microelement, such as a mirror member of SLM, in view of the above-mentioned background, it is dramatically important to decrease hysteresis.

[0006]

Therefore, there is SUBJECT of this invention in providing the improved movable microelement which solves the problem mentioned above or is reduced at least.

[Means for solving problem]

[0007]

In the 1st embodiment, this invention is estranged and arranged from the surface which has at least one electrode, and movable microelement with few hysteresis or hysteresis effects is provided. At least one return component is connected to said movable microelement. An address electrode is allocated on said surface and electrostatic suction of said movable microelement is possible. The address of said address electrode is carried out to the 1st potential. Said movable microelement is first set as the 2nd potential that forms a non-address state, and said movable microelement is changed from said 2nd potential to the 3rd potential that forms an address state in time  $\Delta t$  before a predetermined pulse signal is sent. Said movable microelement is maintained by said address state between time  $\Delta t + \Delta t'$ .

[0008]

In another embodiment of this invention, said movable microelement is returned to said non-address state after said address state by returning said 3rd potential to said 2nd potential.

[0009]

In another embodiment of this invention, said movable microelement is changed by electrostatic \*\*\*\* after said address state.

[0010]

In another embodiment of this invention, said predetermined pulse signal can clear the potential difference between said address electrode and said movable microelement, and, thereby, returns said movable microelement to said electrostatic \*\*\*\*.

[0011]

In another embodiment of this invention, said given signal is an electromagnetic radiation signal turned to said movable microelement.

[0012]

In another embodiment of this invention, said given signal is an electrical signal with possible making the discharge of a capacitor by which loading is carried out in said 1st potential start while being connected to said address electrode.

[0013]

In another embodiment of this invention, said time  $\Delta t + \Delta t'$  is shorter than 10 ms.

[0014]

In another embodiment of this invention, said time delta  $t + \Delta t'$  is shorter than 10 microseconds.

[0015]

In another embodiment of this invention, the value of said 2nd potential, It is substantially equal to the half of the maximum potential by which an address is carried out to said address electrode which forms non-deflection status in both the maximum potential and minimum potential by which an address is carried out to said address electrode, and said 3rd potential is substantially equal to said minimum potential by which an address is carried out to said address electrode.

[0016]

In another embodiment of this invention, said movable microelement is supported along with the omitted portion by the twist hinge of the couple which forms the axis-of-torsion heart.

[0017]

In another embodiment of this invention, said movable microelement, It is supported by the member rotates of the couple which forms the tiltable shaft heart along with the omitted portion, and said return component, While returning said movable microelement in non-deflection status, it is at least one crookedness hinge which can permit that can come, simultaneously said movable microelement tilts by the circumference of said tiltable shaft heart.

[0018]

In another embodiment, further, this invention has at least one crookedness hinge which can permit that can come, simultaneously said movable microelement rotates by the circumference of said tiltable shaft heart while returning said movable microelement in non-deflecting positions.

[0019]

In another embodiment of this invention, said movable microelement, While returning said movable microelement to a relaxed state along with one of omitted portions, it is supported by the crookedness hinge of the couple which can permit carrying out vertical migration to said surface where it can come, simultaneously said movable microelement has said at least one electrode.

[0020]

In another embodiment of this invention, said movable microelement, While returning said movable microelement to a relaxed state along with two of the omitted portions, it is supported by two pairs of crookedness hinges which can permit carrying out vertical migration to said surface where it can come, simultaneously said movable microelement has said at least one electrode.

[0021]

Said crookedness hinge is attached to the polygonal corner in another embodiment of this invention.

[0022]

Said crookedness hinge is attached to the polygonal surface part in another embodiment of this invention.

[0023]

In another embodiment of this invention, at least one of the at least one and/or said axis-of-torsion hearts of said crookedness hinge is winding form.

[0024]

In another embodiment of this invention, said surface has further the counterelectrode estranged from said address electrode to the side, and electrostatic suction of said movable microelement is possible for said address electrode and said counterelectrode.

[0025]

In another embodiment of this invention, said predetermined pulse signal can clear the potential difference between said address electrode and said counterelectrode, and returns said movable microelement to said non-address state by this.

[0026]

In another embodiment of this invention, said predetermined pulse signal can clear the potential difference between said address electrode and said counterelectrode, and returns said movable microelement to electrostatic \*\*\*\*\* by this.

[0027]

In another embodiment of this invention, said given signal is electromagnetic radiation turned to said movable microelement.

[0028]

Said given signal is [ in / further / another embodiment ] an electrical signal which can discharge the capacitor of this invention by which loading is carried out in said 1st potential while being connected to said address electrode.

[0029]

In another embodiment of this invention, said predetermined pulse signal synchronizes with said time delta  $t + \Delta t'$  so that said time  $\Delta t'$  may become equal substantially with the pulse length of said given signal.

[0030]

Said reflecting member is one movable microelement of said embodiments here about a spatial-light-modulation machine provided with the reflecting member of further plurality [ this invention ].

[0031]

In another embodiment of this invention, said reflecting member is set as one potential via one common element pin.

[0032]

In another embodiment of this invention, said counterelectrode is set as one potential via one common opposite pin.

[0033]

In another embodiment of this invention, it changes said all reflecting members substantially into the same time and an address state.

[0034]

Further, this invention is arranged in an image formation face, and relates to the equipment for patterning the work which induces electromagnetic radiation.

[0035]

The source in which this invention emits electromagnetic radiation towards an objective surface in the 1st embodiment, Provide the computer control reticle which received said electromagnetic radiation in said objective surface, and was constituted so that this electromagnetic radiation might be relayed towards said work arranged in said objective surface and which has two or more reflective movable microelement, and here, In that in which said computer control reticle has two or more reflective micro components, said reflective micro component is characterized by being one movable microelement of said embodiments.

[0036]

Said surface has at least one electrode here about a method for this invention to reduce further the hysteresis of the movable microelement estranged and arranged from the surface.

[0037]

In the 1st embodiment, this invention includes the following processes,

Said movable microelement is set as the 2nd potential that forms a non-address state,

An address electrode is arranged on said surface and electrostatic suction of said movable microelement is possible for it here where the address of the address electrode is carried out to the 1st potential,

In time  $\Delta t$  before said movable microelement is sent to a predetermined pulse signal, it changes from said 3rd potential to the 4th potential that forms an address state,

Said movable microelement is maintained in said address state between time  $\Delta t + \Delta t'$ .

[0038]

In another embodiment, this invention includes the following processes further,

By changing said movable microelement from said 3rd potential to said 2nd potential, it returns to said non-address state.

[0039]

In another embodiment, this invention includes the following processes further,

Said movable microelement is changed after said address state at electrostatic \*\*\*\*\*.

[0040]

In another embodiment, this invention includes the following processes further,

With said predetermined pulse signal, the potential difference between said address electrode and said movable microelement is cleared, and, thereby, said movable microelement is returned to said electrostatic \*\*\*\*\*.

[0041]

In another embodiment of this invention, said given signal is an electromagnetic radiation signal turned to said movable microelement.

[0042]

In another embodiment of this invention, said given signal is an electrical signal with possible making the discharge of a capacitor by which loading is carried out in said 1st potential start while being connected to said address electrode.

[0043]

In another embodiment of this invention, said time  $\Delta t + \Delta t'$  is shorter than 10 ms.

[0044]

In another embodiment of this invention, said time  $\Delta t + \Delta t'$  is shorter than 10 microseconds.

[0045]

In another embodiment of this invention, said 2nd potential, It is substantially equal to the half of the maximum potential by which an address is carried out to said address electrode which forms non-deflection status in both the maximum potential and minimum potential by which an address is carried out to said address electrode, and said 3rd potential is substantially equal to said minimum potential by which an address is carried out to said address electrode.

[0046]

In another embodiment, this invention includes the following processes further,

Said movable microelement is supported along with the omitted portion with the twist hinge of the couple which forms the axis-of-torsion heart.

[0047]

In another embodiment, this invention includes the following processes further,

Along with the omitted portion, said movable microelement here where it supports by the member rotates of the couple which forms the tiltable shaft heart said return component, While returning said movable microelement in non-deflection status, it is at least one crookedness hinge which can permit that can come, simultaneously said movable microelement rotates by the circumference of said tiltable shaft heart.

[0048]

In another embodiment, this invention includes the process of further the following,

Said movable microelement is returned with at least one crookedness hinge.

[0049]

In another embodiment, this invention includes the following processes further,

While returning said movable microelement to a relaxed state along with one of omitted portions, said movable microelement, It supports with the crookedness hinge of the couple which can permit carrying out vertical migration to said surface where it can come, simultaneously said movable microelement has said at least one electrode.

[0050]

In another embodiment, this invention includes the following processes further,

While returning said movable microelement to a relaxed state along with two of the omitted portions, said movable microelement, It supports with the crookedness hinge of the couple which can permit carrying out vertical migration to said surface where it can come, simultaneously said movable microelement has said at least one electrode.

[0051]

Said crookedness hinge is attached to the polygonal corner in another embodiment of this invention.

[0052]

Said crookedness hinge is attached to the polygonal surface part in another embodiment of this invention.

[0053]

In another embodiment, this invention includes the following processes further,

At least one of the at least one and/or said axis-of-torsion hearts of said crookedness hinge is winding form.

[0054]

In another embodiment of this invention, said movable microelement is one movable microelement of said embodiments.

[0055]

In another embodiment, this invention includes the following processes further,

Said time  $\Delta t + \Delta t'$  synchronizes said predetermined pulse signal with said time  $\Delta t + \Delta t'$  so that it may become equal substantially with the pulse length of said given signal.

[Best Mode of Carrying Out the Invention]

[0056]

For a still more perfect understanding of this invention and its advantage, the following explanation is referred to with reference to an accompanying drawing.

[0057]

Drawing 1 a is illustrating the 1st embodiment of movable microelement, for example, micro machine member, \*\* with little hysteresis by this invention. Said movable microelement can be used as the mirror of a spatial-light-modulation machine (Spatial Light Modulator:SLM), for example. Said mirror can operate in the digital mode in which ON and the OFF state of this mirror member which are analog modes in order to operate the deflection degree of this mirror member selectively as a function of an electrical input, or are formed of a maximum deflection and un-deviating are expressed. According to how it acts physically, as a function of said input signal, this mirror (movable microelement) may be linearity mostly, and the deviation of said mirror member may have it. [nonlinear]

[0058]

in this example, said movable microelement 10 was supported by the twist hinge 60 of the couple along with the one omitted portion — it is a rectangular reflecting member mostly. This reflecting member can be made into arbitrary form, such as a polygon, circular, or an ellipse form, for example. Said hinge is twisted along with it and forms an axial center. Said twist hinge extends from said movable microelement 10, and is supported by the support component 50. This support component is supported on the base material 20. Said movable microelement 10, said twist hinge 60, said support component 50, and said base material, For example, since it can form from the same materials, such as silicon and aluminum, and they can be etched from one base material for a person skilled in the art using well-known etching technology, it is unnecessary to explain them further.

[0059]

Said base material is provided with the following.

The conductive address electrode 40.

The conductive counterelectrode 30 as an option.

These address electrodes 40 and the counterelectrode 30 as an option are connected to the address circuit (not shown) of the lower part formed in said base material 20. Said address electrode is connected to a capacitor and these capacitors hold the address voltage by which an address is carried out to said electrode. The counterelectrode 30 and the address electrode 40 of said option are mutually estranged on said surface 20 in the side, and electrostatic suction of said movable microelement 10 is possible for them. Said twist hinge 60 is rotated or twisted with said movable microelement 10, and provides the stability as mechanical energy. When voltage is not built to the counterelectrode 30 and address electrode of said movable microelement and said option, in the following explanation, it is supposed that it is said movable micro component in the \*\*\*\*\* deflecting positions which are indicated as an electric non-suction state and which are the usual flats. A counter direction can be made to rotate said movable microelement by shifting said address voltage from an address electrode to a counterelectrode.

[0060]

Drawing 1 b is illustrating the 2nd embodiment of movable microelement with little hysteresis by this invention. This 2nd embodiment has the two flexible hinges 70 supported by the support component 50 while being connected to said movable microelement 10 in addition to said 1st embodiment. When said movable microelement 10 deviates by the circumference of said twist axial center formed by said twist hinge 60, these flexible hinges 70 also provide stability, and are changed or crooked. In this embodiment, said flexible hinge 70 is L form in which one of ends was connected to said support component 50, and that other end was connected to said movable microelement 10. One side of these flexible hinges was connected to the same side as one side of said twist hinge, the flexible hinge of another side was connected to the same side as the twist hinge of another side, and these flexible hinges are mutually estranged to the diagonal direction on said movable microelement.

[0061]

Drawing 1 c is illustrating the 3rd embodiment of movable microelement with little hysteresis by this invention. The point of difference of this embodiment and said 2nd embodiment has said movable microelement 10 in having the two pivotal support parts 65 instead of the aforementioned torsion hinge 60. These pivotal support parts are supported by said support component 50. These pivotal support parts are located in the crevice 55 formed in the upper part of said support component 50, only the tilt in the circumference of the tiltable shaft heart of said movable microelement 20 is permitted, and that it separates and moves to the side from the position conforms to the size of said pivotal support part 65 so that it may not approve.

[0062]

Stability is provided by the flexible hinge 70 changed or crooked when said movable microelement 10 deviates by the circumference of said tiltable shaft heart formed of said pivotal support part 60. In this embodiment, said flexible hinge 70 is L form in which one of ends was connected to said support component 50, and that other end was connected to said movable microelement 10. One side of these flexible hinges was connected to the same side as one side of said pivotal support part, the flexible hinge of another side was connected to the same side as the pivotal support part of another side, and these flexible hinges are mutually estranged to the diagonal direction on said movable microelement.

[0063]

Drawing 1 d is illustrating the 4th embodiment of movable microelement with little hysteresis by this invention. There is a point of difference with the above-mentioned embodiment indicated with reference to this 4th embodiment and drawing 1-3 in the movable microelement 10 carrying out vertical movement in the vertical direction to the surface 20 to which at least one address electrode 40 was attached. The flexible hinge 70 is supported by the support component 50 while being connected to said movable microelement 10. Said flexible hinge 70 is changed or crooked, when stability is provided and said movable microelement 10 carries out vertical movement perpendicularly substantially to said surface 20. In this embodiment, said flexible hinge 70 is the rectangular shape with which one of ends was connected to said support component 50, and that another end was connected to said movable microelement 10. Said flexible hinge is attached to the 2 opposed faces of the movable microelement 10 of said rectangle. Preferably, said hinge is in agreement with one of the symmetrical axial centers of said movable microelement 10. In another embodiment, at least, the flexible hinge 70 of a couple is attached to said movable microelement 10, and these already corresponds with another axis of symmetry of this movable microelement 10. In the embodiment of drawing 1 d, although said address electrode 40 is the same form in the same size as substantially as said movable microelement 10, it is also possible to both differ the form and size of this address electrode from said movable microelement 10. Said address electrode can also be divided into two or more address electrodes 40 again. Other movable microelement (the same pixel) in the state where it maintained to the slackened position (The state which does not have an electrostatic suction force between the movable microelement 10 and the address electrode 40), Destructive interference is attained by what the movable microelement 10 is

caudad' shifted for (one fourth of the wavelength used in order to hit this component).

[0064]

Drawing 1 e is illustrating the 5th embodiment of movable microelement with little hysteresis by this invention. Said flexible hinge 70 is L form, the number of these flexible members 70 is not 2 but 4, and the point of difference of this 5th embodiment and said 4th embodiment has it in those each sets being substantially in agreement with a diagonal symmetrical axial center further.

[0065]

Drawing 2 shows the abbreviated flow chart of the method of reducing hysteresis by this invention.

[0066]

The 1st process 110 expresses the process of setting said movable microelement 10 as the 2nd potential. Said 2nd potential can be made into the potential which is a half of the value of the maximum potential by which an address is carried out to said address electrode, for example. Said 3rd electrode forms a non-address state.

[0067]

The 2nd process 120 expresses the process of carrying out the address of the address electrode 40 to the 1st potential. Said 1st potential can be made into the any value between minimum potential and said maximum potential, said minimum potential can be made into earth potentials, and said maximum potential can be set to 20V here. Said address electrode 40 is arranged on said surface 20, and electrostatic suction of said movable microelement 10 is possible for it.

[0068]

The 3rd process 130 expresses the process of changing said movable microelement from said 2nd potential to the 3rd potential that forms an address state. The change to this 3rd potential is performed to time  $\Delta t$  before a predetermined pulse signal is sent. Said 3rd potential can be made into earth potentials, for example.

[0069]

The 4th process 140 is shorter than 10 ms, and expresses the process of maintaining said movable microelement by another embodiment in the one embodiment in time equal to  $\Delta t + \Delta t'$  shorter than 10 microseconds, and said address state.  $\Delta t$  should correspond to the time for discharging a capacitor made into several microseconds or less than it according to the type and size of the capacitor, for example.  $\Delta t$  — the any value of the range of a sub second — it can be most preferably set as the value for 10 or less microseconds about 10 or less ms. Although  $\Delta t$  is longer than  $\Delta t'$ , it can also usually apply the opposite composition. Said given signal can be used as pulse electromagnetic radiation beams, such as a pulse laser, for example.  $\Delta t$  synchronizes with the pulse length of said pulse signal in one embodiment.

[0070]

After changing into said time  $\Delta t + \Delta t'$  aforementioned address state, said movable microelement is returned to said 2nd potential, or is changed to electrostatic \*\*\*\*\*.

[0071]

A spatial-light-modulation machine can be provided with two or more mirrors which can be considered as the type of the movable microelement arranged at a one-dimensional sequence or two-dimensional array form. In said SLM, it can connect with one voltage plane and all the movable microelement, i.e., mirror surfaces, can carry out an address to this flat surface in one of the input pins, and what is called an element pin. The same thing is applied also to all the counterelectrodes 30 on said base material 20. Namely, an address is possible for both them using what is called an opposite pin. When said counterelectrode 30 is maintained by earth potentials, said address electrode, An address is carried out to earth potentials, movable microelement is set as either of said 3rd or 4th potential, and since the potential difference between an address electrode and movable microelement is equal to the potential difference between a counterelectrode and movable microelement, movable microelement is not deflected. However, it is also possible to provide the bending part to a small lower part among both the edge of movable microelement depending on the thickness. This bending part sets the thickness of said movable microelement constant, and increases with the increase in the voltage concerning this movable microelement. All the mirrors of said SLM are substantially changed from said 3rd potential from said non-address state simultaneously to said 4th potential, i.e., said address state. all the mirrors of SLM — moreover — it is in said address state the same time ( $\Delta t + \Delta t'$ ) substantially — this — the hysteresis of these mirror members — removal — or it decreases at least. These mirror members have so few degrees influenced by a hysteresis effect (hysteresis) that the time when these mirror members are in an address state is short. That is, the influence on the mirror member by said hysteresis effect decreases, so that the duty cycle which the time when a mirror member is in an address state carries out comparatively, and is defined is short. A mirror member not only stops at said address state short time, but in the same time, i.e.,  $\Delta t + \Delta t'$ , all mirror members stop at said address state substantially.

[0072]

If movable microelement is set as 10V and a counterelectrode is maintained by earth potentials, in both cases where an address is carried out to the case where the address of the address electrode is carried out to the minimum voltage 0V, and the maximum voltage 20V, the movable microelement 10 will stop at non-deflection status substantially. This is not important for the mark of voltage in electrostatic force, and he can understand it by recognizing that it is always a suction state. An example of the deviation as a function of the potential difference between an address electrode and movable microelement is illustrated by drawing 3. In drawing 3, a movable component is in zero potential, and the potential of the address electrode is changing, moving a deflection degree up and down by turns, and measuring it. In this figure, the movable microelement can understand that it is non-deflection status substantially below by a certain potential difference (this example 10V). The electromagnetic force between movable microelement and an address electrode receives reaction according to the mechanical stability of said twist hinge 60 (singular number or plurality) and/or the flexible hinge 70. According to the type and number of these twist hinge and/or flexible hinges which were attached to movable microelement, said deviation as a function of the potential difference between an address electrode and movable microelement can change.

[0073]

This means that it is possible to carry out an address to all the pixels (namely, rotation member), without deflecting substantially the rotation member which corresponds to a rotation member using 10V. For example, if the voltage to movable microelement shifts to 0 volt just before said electromagnetic radiation signal turned to said movable microelement, and the predetermined signal which can be carried out, all the movable microelement will be in said request deflection status simultaneously. If said electromagnetic radiation is equivalent to movable microelement, all the capacitors connected to said address electrode on a base material will be discharged, and movable microelement will return to said un-deviating and an electromagnetism non-suction state immediately. Thus, the duty cycle which deflects all the movable microelement is maintainable as a very small thing based on the switching time of miller voltage. If  $\Delta t + \Delta t'$  is maintained at 10 microseconds, supposing the frequency of said pulse

signal will be 1000 Hz, the duty cycle of perfect deflection status will be 1%.

[0074]

When the address of said address electrode is carried out to said maximum or the minimum (grounding) potential, movable microelement is set as the half of the value of maximum potential and a counterelectrode is maintained by earth potentials, the address of the movable microelement is not deflected and carried out. In the case of each value between maximum potential and minimum potential, the address of the movable microelement is not deflected and carried out. The worst case is a case where address voltage is a half of the value of the maximum. In this case, since both an address electrode and movable microelement are 10V, power is not generated among them. Next, a counterelectrode pulls movable microelement caudad with the power corresponding to 10V. However, to a fortunate thing, this deviation is comparatively small by the nonlinear action of movable microelement so that I may be understood from drawing 3.

[0075]

Drawing 4 is illustrating the embodiment of the equipment 100 for patterning the work 60 coated by the layer of electromagnetic radiation induction material. This equipment 100 is provided with the following.

The source 11 which emits electromagnetic radiation.

The 1st lens system 50.

Computer control reticle 30.

The 2nd lens system 20, the spatial filter 70, the 3rd lens system 40, and the work 60.

[0076]

In this application from the infrared rays (IR) which carry out said source 11 to from 780 nm to about 20 micrometers, and are defined, The radiation of the wavelength range to the extreme ultraviolet rays (EUV) defined from 100 nm as a range of all possible [ that the radiation is treated as electromagnetic radiation ] low wavelength can be emitted. This source 11 emits radiation to pulse form or continuous state. The discharge radiation from the continuous radiation line source 11 can be formed in pulse form radiation with the shutter located in the radiation course between this radiation source 11 and said computer control reticle 30. Said radiation source 11 can be made into a 1000 Hz [ in 248 nm of pulse outputs, about 10 ns of pulse length, and repetitive speed ] KrF excimer laser as an example. Said repetitive speed may be 1000 Hz or less, and may be not less than 1000 Hz. Said 2nd lens system 20 can be made into the assembly of a simple lens or two or more lenses. This 2nd lens system 20 distributes uniformly the radiation emitted from said radiation source 11 on the surface of said computer control reticle 30.

[0077]

Said 2nd lens system 20 can have the exit pupil in infinite distance, and means that this has the parallel center shaft heart of the cone of radiation. The center shaft heart of said radiation cone of said objective surface is [ in / in accordance with the position of said computer control reticle 30 / at this embodiment / said objective surface ] parallel. Said computer control reticle 30 can be used as a spatial-light-modulation machine (SLM). In this embodiment, this SLM has all the information required to pattern said work 60 whole at a single moment.

[0078]

The spatial-light-modulation machine 30 can be made into a reflection type or a transmission type thing. In the embodiment illustrated by drawing 1, said SLM is the reflection type SLM. Reflection type spatial-light-modulation machines are two types, i.e., a deviation type and a phase type, and \*\*\*\*\*. In the case of a micro mirror, especially the difference between these may be visible to a small thing, but the phase type SLM. The pixel of the deviation type SLM makes one side deflect a reflective beam geometrically to erasing the beam of a reflecting direction by destructive interference, so that a reflective beam may separate from the caliber of an image formation lens. Usually, the micro mirror of the deviation type SLM is more greatly displaced as compared with the micro mirror of the phase type SLM from the flat position formed of the surface of loose SLM whose surface of a micro mirror is a flat. For ultraprecise patterning which is performed by this invention, the phase type SLM is superior to the deviation type SLM.

[0079]

Since it is possible all the parts of the surface and for a hinge and a supporting post to participate in said destructive interference, and to attain perfect extinction further as for the phase type SLM, contrast is more excellent in the 1st.

[0080]

The system which acts by 2nd deflecting radiation in one side is difficult to form symmetrically by the circumference of an optic axis in a middle change angle, and when a focus is changed, there is a possibility that functional instability may occur. The phase type SLM can be built according to a micro processing mirror, what is called a micro mirror, or the continuation mirror surface on a supporting substrate, and said mirror surface can be changed using an electrical signal.

[0081]

For example, although the viscoelasticity layer controlled by electrostatic electric field can be used for said continuation mirror, It comes out enough especially by modification of about several nanometers, and, in the case of a certain very short wavelength, it is possible similarly that electric field or others are electric and to use the piezo-electric solid disk transformed by the reflector controlled magnetically or thermally. In the description of the following of this application, although premised on the electrostatic control micro mirror matrix (one dimension or two dimensions), Other composition which was mentioned above, such as micro mechanical SLM which uses the transmission type or the reflection type SLM based on a LCD crystal or electrooptic material, a piezo-electric formula, or electrostriction operation as those abnormal-conditions mechanisms, is also possible.

[0082]

Said SLM is programmable equipment which generates the output radiation modulated by the separate input from a computer. SLM answers the data supplied from a computer and simulates an operation of a mask through generating of luminosity or a dark pixel. For example, the phase type SLM is an array of the etched solid mirror. Each micro mirror component is hung above the silicon base material by the twist hinge which another supporting post or an adjoining mirror is not, but can be supported by \*\*. The address electrode is arranged under these micro mirror components. One micro mirror expresses one pixel to an objective surface. The sizes should differ by whether to be large according to the optical system, i.e., is [ whether the optical system is an expansion type and ] it a non-expanding formula?, although the pixel of an image formation face is defined as what has the same geometrical form as a micro mirror here, or small.

[0083]

Said micro mirror and an address electrode act as a capacitor, and to the voltage to a micro mirror with the voltage applied to an

address electrode. Said twist hinge which has hung the micro mirror is twisted, it permits that a micro mirror rotates by this, and phase contrast is made by it. According to the voltage given, any state from a flat position to a perfect rotary place can take rotation of a micro mirror. The micro mirrors of the perfect rolling state whose length of the neighborhood is about 16 micrometers and which has the rectangular surface substantially are usually 8mRad. More generally said full rotation micro mirror, 1/4 of the wavelength which is measurement with parallel edge and is used to a shaft center -- rotating -- or -- or in the case of the micro mirror which moves vertically to said surface, the difference between the maximum state and the minimum state is 1/4 of the wavelength which is parallel measurement and is used to the surface of said micro mirror.

[0084]

The projection system 80 is provided with the following.

In this embodiment, it is said 3rd lens system 40.

Spatial filter 70.

Said 1st lens system 50.

Said 3rd lens system 40 and the spatial filter 70 are collaboration, and what is generally called the Fourier filter is formed.

[0085]

Said spatial filter 70 is the hole formed in the plate in this embodiment, this hole is diffracted by the primary and higher order degree -- all the orders of diffraction are prevented substantially -- as -- size composition -- and the arrangement configuration is carried out, for example, said hole can be arranged from said 3rd lens system 40 to a focal distance position. In the focal plane which acts also as a pupil side of said 1st lens system 50 simultaneously, the reflected radiation is collected by the 3rd lens system 40. Said hole can carry out the cutout of the light of the primary or higher order order of diffraction of the micro mirror in SLM by which the address was carried out, on the other hand the radiation from the non-address mirror surface can pass through this hole. As a result, the space image by which intensity modulation was carried out on the work 60 is formed like the conventional lithography. For the optimal picture contrast, the diffraction pattern of SLM by which all the pixels were changed should contain only the light of primary and the order of diffraction higher order than it without the radiation of zeroth order.

[0086]

Said 1st lens system 50 has that exit pupil on the infinite edge in this embodiment. That is, the medial-axis heart of the cone of the radiation of the image formation face formed of the position of the work 60 is parallel.

[0087]

Said work 60 can be used as the base material provided with sensitization sides, such as a semiconductor device and a photo mask for display panels. It can also be considered as the semiconductor wafer coated by the photosensitive layer again. Since this invention does not have a use directly only in patterning of semiconductor device Bataan, a display panel, integral-type Optical Devices Division, and electronic interconnection structure, it is available also to patterning of the type of others, such as security patterning. Here the term of patterning only not only in exposure of photoresist and a photographic emulsion, I should be understood by the large meaning also meaning an operation of the radiation to other radiation induction media (for example, dry process paper) started with radiation or heat, such as ablation or a chemical process. The processed wafer of this invention is available again also to the wafer restoration reworked by radiation.

[0088]

Said work 60 can also be arranged on the moving stage where it moves at a fixed speed. In this case, said electromagnetic radiation is the pulse form electromagnetism source 11 which irradiates with said computer control reticle 30 and in which each pulse which turns image formation to the work 60 up irradiates with the portion from which that work 60 differs. For example, said computer control reticle 30 which can be set to SLM operates so that reconstruction is possible, so that all the arrays of the micro mirror may form an exact picture on the work 60 to each pulse.

[0089]

First, the binary pattern from a CAD layout is changed into the data set of SLM data. This data is transmitted to SLM and many micro mirrors change a position here according to the control electronic structure included in it. Thereby, a non-deviating pixel expresses the bright field on a work. Each specific cone of the radiation of a picture pixel defined above in said image plane corresponds to one specific object pixel of said computer control reticle 30 which can be used as a single micro mirror, for example. Each micro mirror can be made into a movable microelement type thing as mentioned above:

[0090]

The pattern on the work 60 is formed with many SLM stamps (stamps). These stamps should overlap selectively mutually. Grouping of both these stamps is carried out to a strip, and each strip has at least two stamps, and covers the overall length of a mask base material, or its part there. Said stamp on a strip is arranged as the line or sequence of a one-dimensional line, for example, a stamp.

[0091]

Drawing 5 is illustrating an example of the method by which the SLM stamp 150 is arranged on the work 60. The work 60 is covered by the lines 11, 12, 13, 14, 15, 16, 17, and 18 of the SLM stamp 150, the eight sequences c1, c2, c3, c4, c5, c6, c7, and c8 in this figure. Actually, although a work is covered with the SLM stamp of thousands, the pattern of only 8x8 is illustrated for clear-izing. Each stamp has many pixels and usual has millions of pixels. A strip can be made into the part of a perfect line, 11, 12, 13, 14, 15, 16, 17 and 18, or such a line. In accordance with the direction 11, 12, 13, 14, 15, 16, 17, and 18 of a strip, for example, lines, while said radiation source emits radiation to SLM so that it may carry out image formation of the pattern on it to a work, the supporting structure which carries a work moves. Completion of one strip will move the supporting structure in the equal direction substantially [ size / a vertical direction and / of the stamp of this direction ] substantially to the direction of a strip.

[0092]

A history (imprinting) is a cumulative material operation which appears as change in which an actuator/picture element position increases gradually, when all the parameters are kept constant in deflection status. When an actuator is neglected by sufficient time and non-deflection status, it is saved somewhat and appears (cure out). Both accumulation of a history and preservation of a history are nonlinear operations. Thus, it depends for the position at the given time not only on the electrostatic force which the actuator has received at that time but on the history of a deviation of this specific actuator. Therefore, the response of an actuator becomes inaccurate after a certain time. That is, the placement accuracy of the feature on the mask in a lithography process falls.

[0093]

In another embodiment of this invention, said history is reduced substantially completely at least.

[0094]

It may be longer than the time between the laser flashes of two times during time to process a perfect pattern on a work, and the interval of the time in which a pattern is not then formed may exist. Laser does not irradiate with SLM during the return stroke which is the time which needs said supporting structure body for another strip to begin, and pass and move from the end of one completed strip. The pattern on SLM is not acting on the last pattern on a mask during this return stroke. Therefore, it is possible to operate SLM by desirable arbitrary methods, although said cumulative history operation on another strip from one strip is reduced or neutralized during the time of a return stroke.

[0095]

When printing a specific pattern on a work, the deviation time and the grade of a deviation of each pixel may be monitored between each strip. For example, the reaction over the history under return stroke can be attained by shifting each actuator to reverse or a negative state. This can be performed by using the set of amplitude, address times, or the amplitude and the address times that detects correctly the history generated during exposure (singular number or plurality) of the strip (singular number or plurality) before that to each actuator in SLM.

[0096]

It is also possible to use the feedback system which monitors the momentary history operation generated about each actuator, and cancels it after that. This can be performed by using the monitor system based on an in-system (in-chamber) camera which measures the contrast from each actuator, when the address of all the actuators is carried out to the same amplitude. Contrast differentiation (derivative) uses the collective address position of the actuator which is a possible peak price in the mask writer system, and measurement should be performed immediately after each strip. Then, the information from this measurement can be used and amplitude and address times can be fine-adjusted for history reaction addressing in the remaining portion of a return stroke.

[0097]

Instead of returning as time for reducing or canceling a history operation, and using a stroke, this cancellation or reducing method may be performed at what kind of time under processing of a perfect pattern. For example, a specific actuator may stop an image formation process, when [ given ] it is in given time and an address state, the quantity of a deviation may be taken into consideration in that case, or it is not necessary to put in.

[0098]

Cancellation of a history may be performed at one or more processes. After repealing each actuator from the information about deviation time and a deflection degree in the given time interval calculated from the picture photographed, for example by the CCD camera, further fine adjustment may be performed from the picture taken from SLM by which the history was canceled. every -- a SLM pixel is set as a given state and compensation in the address function for the further fine adjustment of that actuator or each pixel is performed by the grade of the difference from this state.

[0099]

Thus, although the specific embodiment of the equipment for patterning a work until now has been indicated, it does not have intention of such concrete reference being regarded as limitation to the range of this invention except for being indicated to Claims. Although this invention has been indicated in relation with the specific embodiment, it is understood that a person skilled in the art will think out also in the other embodiments, and it is meant by Claims until now with that in which all such change composition is included.

[Brief Description of the Drawings]

[0100]

[Drawing 1 a] The hysteresis by this invention is illustrating few 1st embodiment of movable microelement.

[Drawing 1 b] The hysteresis by this invention is illustrating few 2nd embodiment of movable microelement.

[Drawing 1 c] The hysteresis by this invention is illustrating few 3rd embodiment of movable microelement.

[Drawing 1 d] The hysteresis by this invention is illustrating few 4th embodiment of movable microelement.

[Drawing 1 e] The hysteresis by this invention is illustrating few 5th embodiment of movable microelement.

[Drawing 2] The abbreviated flow chart of the method of reducing the hysteresis by this invention is shown.

[Drawing 3] The schematic illustration of the deviation as a function of the potential difference between an address electrode and movable microelement is shown.

[Drawing 4] The optical system for patterning the base material coated by the electromagnetic radiation induction material layer is illustrated.

[Drawing 5] The composition of the SLM stamp on a work is illustrated.

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[Translation done.]

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

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**WRITTEN AMENDMENT**


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[Written Amendment]

[Filing date]Heisei 15(2003) August 4 (2003.8.4)

[Amendment 1]

[Document to be Amended]Claims

[Item(s) to be Amended]Whole sentence

[Method of Amendment]Change

[The contents of amendment]

[Claim(s)]

[Claim 1]

Are estranged and arranged from the surface (20) which has at least one electrode, are movable microelement with little hysteresis (10), and to said movable microelement (10). In that by which at least one return component (60, 70) is connected, an address electrode (40) is allocated on said surface (20), electrostatic suction of said movable microelement (10) is possible, and the address of said address electrode (40) is carried out to the 1st potential, In time deltat before a predetermined pulse signal is first sent to said movable microelement (10) to said movable microelement (10), A non-address state is set as the 2nd potential to form, and said movable component, Movable microelement (10) reduced when it changes from said 2nd potential to the 3rd potential that forms an address state and said history operation decreases an address state duty cycle of said movable microelement (10).

[Claim 2]

Movable microelement (10) which is the movable microelement (10) of Claim 1, and is returned to said non-address state after said address state when said movable microelement (10) returns said 3rd potential to said 2nd potential.

[Claim 3]

Movable microelement (10) from which it is the movable microelement (10) of Claim 1, and said movable microelement (10) is changed by electrostatic \*\*\*\*\* after said 2nd potential state.

[Claim 4]

Are the movable microelement (10) of Claim 3 and said predetermined pulse signal, Movable microelement (10) which can clear said address electrode (40) and potential difference between said movable microelement (10), and returns said movable microelement (10) to said electrostatic \*\*\*\*\* by this.

[Claim 5]

Movable microelement (10) which is Claim 1 or the movable microelement (10) of 4, and is the electromagnetic radiation by which said predetermined pulse signal is turned to said movable microelement (10).

[Claim 6]

Movable microelement (10) which is Claim 1 or the movable microelement (10) of 4, and is an electrical signal with possible making discharge of a capacitor by which loading is carried out in said 1st potential start while said predetermined pulse signal is connected to said address electrode (40).

[Claim 7]

Movable microelement (10) which is the movable microelement (10) of Claim 1 and is maintained by time deltat+deltat' in which said movable microelement is shorter than 10 ms, and said address state.

[Claim 8]

Movable microelement (10) which is the movable microelement (10) of Claim 1 and is maintained by time deltat+deltat' in which said movable microelement is shorter than 10 microseconds, and said address state.

[Claim 9]

Are the movable microelement (10) of Claim 1 and a value of said 2nd potential, . In both maximum potential and minimum potential by which an address is carried out to said address electrode (40), form non-deflection status. Movable microelement (10) in which it is substantially equal to a half of maximum potential by which an address is carried out to said address electrode (40), and said 3rd potential is substantially equal to said minimum potential by which an address is carried out to said address electrode (40).

[Claim 10]

Movable microelement (10) which is one movable microelement of the Claims 1-9 (10), and is supported by a twist hinge (60) of a couple with which said movable microelement (10) forms the axis-of-torsion heart along with the omitted portion.

[Claim 11]

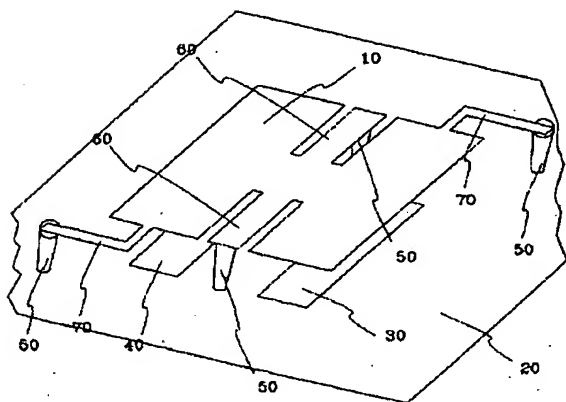
Are one movable microelement of the Claims 1-9 (10), and said movable microelement (10), It is supported by member rotates (65) of a couple which forms the tiltable shaft heart along with the omitted portion, and said return component, Movable microelement (10) which is at least one crookedness hinge (70) which can permit that can come, simultaneously said movable microelement (10) tilts by a circumference of said tiltable shaft heart while returning said movable microelement (10) in non-deflection status.

[Claim 12]

Are the movable microelement (10) of Claim 10, and further, while returning said movable microelement in non-deflection status, Movable microelement (10) which has at least one crookedness hinge which can permit that can come, simultaneously said movable microelement (10) tilts by a circumference of said tiltable shaft heart or said axis-of-torsion heart.

Drawing selection Representative drawing

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[Translation done.]

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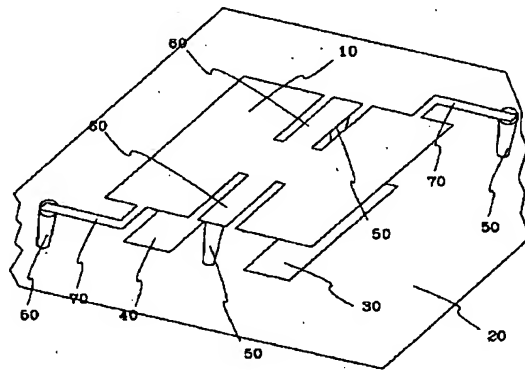
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(54) 【発明の名称】 可動マイクロ素子におけるヒステリシス又は履歴効果を減少させるための方法と装置

## (57) 【要約】

本発明は、少なくとも1つの電極を有する表面から離間して配置されて、履歴又はヒステリシス効果の少ない、可動マイクロ素子に関する。前記可動マイクロ素子には、少なくとも1つの復帰部材が接続されている。前記表面上にはアドレス電極が配設され、前記可動マイクロ素子を静電吸引可能である。前記アドレス電極は、第1電位にアドレスされる。前記可動マイクロ素子は、先ず、非アドレス状態を形成する第2電位に設定され、所定のパルス信号が発信される前の時間  $\Delta t$  において、前記可動マイクロ素子は、前記第2電位から、アドレス状態を形成する第3電位に切り替えられる。前記可動マイクロ素子は、時間  $\Delta t + \Delta t'$  の間、前記アドレス状態に維持される。本発明は、更に、空間光変調器 (SLM)、加工物をパターンニングするための装置、そして、可動マイクロ素子の履歴又はヒステリシス効果を低減する方法にも関する。



## 【特許請求の範囲】

## 【請求項 1】

少なくとも 1 つの電極を有する表面 (20) から離間して配置されて、履歴効果の少ない、可動マイクロ素子 (10) であって、前記可動マイクロ素子 (10) には、少なくとも 1 つの復帰部材 (60, 70) が接続され、前記表面 (20) 上にはアドレス電極 (40) が配設され、前記可動マイクロ素子 (10) を静電吸引可能であり、前記アドレス電極 (40) が、第 1 電位にアドレスされたものにおいて、

前記可動マイクロ素子 (10) は、まず、所定のパルス信号が前記可動マイクロ素子 (10) に対して発信される前の時間  $\Delta t$  において、非アドレス状態を形成する第 2 電位に設定され、前記可動部材は、前記第 2 電位から、アドレス状態を形成する第 3 電位に切り替えられ、前記可動マイクロ素子 (10) が、時間  $\Delta t + \Delta t'$  の間、前記アドレス状態に維持されることを特徴とする可動マイクロ素子 (10)。

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## 【請求項 2】

請求項 1 の可動マイクロ素子 (10) であって、前記可動マイクロ素子 (10) は、前記第 3 電位を前記第 2 電位へ戻すことによって、前記アドレス状態後に、前記非アドレス状態に戻される可動マイクロ素子 (10)。

## 【請求項 3】

請求項 1 の可動マイクロ素子 (10) であって、前記可動マイクロ素子 (10) は、前記第 2 電位状態後に、静電非吸引状態に切り替えられる可動マイクロ素子 (10)。

## 【請求項 4】

請求項 3 の可動マイクロ素子 (10) であって、前記所定パルス信号は、前記アドレス電極 (40) と、前記可動マイクロ素子 (10) との間の電位差をクリア可能であり、これにより、前記可動マイクロ素子 (10) を前記静電非吸引状態に復帰させる可動マイクロ素子 (10)。

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## 【請求項 5】

請求項 1 又は 4 の可動マイクロ素子 (10) であって、前記所定パルス信号は、前記可動マイクロ素子 (10) に向けられる電磁放射である可動マイクロ素子 (10)。

## 【請求項 6】

請求項 1 又は 4 の可動マイクロ素子 (10) であって、前記所定パルス信号は、前記アドレス電極 (40) に接続されるとともに、前記第 1 電位をローディングされるコンデンサの放電を開始させることが可能な電気信号である可動マイクロ素子 (10)。

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## 【請求項 7】

請求項 1～6 のいずれかの可動マイクロ素子 (10) であって、前記時間  $\Delta t + \Delta t'$  は、10 ms よりも短い可動マイクロ素子 (10)。

## 【請求項 8】

請求項 1～6 のいずれかの可動マイクロ素子 (10) であって、前記時間  $\Delta t + \Delta t'$  は、10  $\mu s$  よりも短い可動マイクロ素子 (10)。

## 【請求項 9】

請求項 1 の可動マイクロ素子 (10) であって、前記第 2 電位の値は、前記アドレス電極 (40) に対してアドレスされる最大電位と最小電位との両方において非偏向状態を形成する、前記アドレス電極 (40) に対してアドレスされる最大電位の半分に実質的に等しく、前記第 3 電位は、前記アドレス電極 (40) に対してアドレスされる前記最小電位に実質的に等しい可動マイクロ素子 (10)。

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## 【請求項 10】

請求項 1～9 のいずれかの可動マイクロ素子 (10) であって、前記可動マイクロ素子 (10) は、その中間部分に沿って、捻れ軸心を形成する一対の捻りヒンジ (60) によって支持されている可動マイクロ素子 (10)。

## 【請求項 11】

請求項 1～9 のいずれかの可動マイクロ素子 (10) であって、前記可動マイクロ素子 (10) は、その中間部分に沿って、傾動軸心を形成する一対の回動部材 (65) によって

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支持され、前記復帰部材は、非偏向状態において前記可動マイクロ素子（１０）を復帰させるとともに、これと同時に、前記可動マイクロ素子（１０）が前記傾動軸心回りで傾動することを許容することが可能な少なくとも１つの屈曲ヒンジ（７０）である可動マイクロ素子（１０）。

【請求項１２】

請求項１０の可動マイクロ素子（１０）であって、更に、非偏向状態において前記可動マイクロ素子を復帰させるとともに、これと同時に、前記可動マイクロ素子（１０）が前記傾動軸心または前記捻れ軸心回りで傾動することを許容することが可能な少なくとも１つの屈曲ヒンジを有する可動マイクロ素子（１０）。

【請求項１３】

請求項１～９のいずれかの可動マイクロ素子（１０）であって、前記可動マイクロ素子（１０）は、その中間部分の１つに沿って、前記可動マイクロ素子（１０）を弛緩状態へ復帰させるとともに、これと同時に、前記可動マイクロ素子（１０）が前記少なくとも１つの電極を有する前記表面（２０）に対して垂直移動することを許容することが可能な一対の屈曲ヒンジ（７０）によって支持されている可動マイクロ素子（１０）。

【請求項１４】

請求項１～９のいずれかの可動マイクロ素子（１０）であって、前記可動マイクロ素子（１０）は、その中間部分の二つに沿って、前記可動マイクロ素子（１０）を弛緩状態へ復帰させるとともに、これと同時に、前記可動マイクロ素子（１０）が、前記少なくとも１つの電極を有する前記表面（２０）に対して垂直移動することを許容することが可能な二対の屈曲ヒンジ（７０）によって支持されている可動マイクロ素子（１０）。

【請求項１５】

請求項１３又は１４のいずれかの可動マイクロ素子（１０）であって、前記屈曲ヒンジ（７０）は、多角形状の可動マイクロ素子（１０）の角部に取り付けられている可動マイクロ素子（１０）。

【請求項１６】

請求項１３又は１４のいずれかの可動マイクロ素子（１０）であって、前記屈曲ヒンジ（７０）は、多角形状の可動マイクロ素子（１０）の面部に取り付けられている可動マイクロ素子（１０）。

【請求項１７】

請求項１０～１６のいずれかの可動マイクロ素子（１０）であって、前記屈曲ヒンジ（７０）の少なくとも１つおよび／又は前記捻れ軸心の少なくとも１つは、曲折形状である可動マイクロ素子（１０）。

【請求項１８】

請求項１～１７のいずれかの可動マイクロ素子（１０）であって、前記表面（２０）は、更に、前記アドレス電極（４０）から側方に離間した対向電極（３０）を有し、前記アドレス電極（４０）と前記対向電極（３０）とは、前記可動マイクロ素子（１０）を静電吸引可能である可動マイクロ素子（１０）。

【請求項１９】

請求項１８の可動マイクロ素子（１０）であって、前記所定パルス信号は、前記アドレス電極（４０）と前記対向電極（３０）との間の電位差をクリア可能であり、これによって、前記可動マイクロ素子（１０）を前記非アドレス状態へ復帰させる可動マイクロ素子（１０）。

【請求項２０】

請求項１８の可動マイクロ素子（１０）であって、前記所定パルス信号は、前記アドレス電極（４０）と前記対向電極（３０）との間の電位差をクリア可能であり、これによって、前記可動マイクロ素子（１０）を静電非吸引状態へ復帰させる可動マイクロ素子（１０）。

【請求項２１】

請求項１９～２０の可動マイクロ素子（１０）であって、前記所定パルス信号は、前記可

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動マイクロ素子（１０）に向けられる電磁放射である可動マイクロ素子（１０）。

【請求項２２】

請求項１９～２０の可動マイクロ素子（１０）であって、前記所定パルス信号は、前記アドレス電極（４０）に接続されるとともに、前記第１電位をローディングされるコンデンサの放電をすることが可能な電気信号である可動マイクロ素子（１０）。

【請求項２３】

請求項１又は１９の可動マイクロ素子（１０）であって、前記所定パルス信号は、前記時間 $\Delta t'$ が、前記所定パルス信号のパルス長と実質的に等しくなるように、前記時間 $\Delta t + \Delta t'$ と同期される可動マイクロ素子（１０）。

【請求項２４】

複数の反射部材を備える空間光変調器であって、前記反射部材が、請求項１～２３のいずれかの可動マイクロ素子（１０）であることを特徴とする空間光変調器。

【請求項２５】

請求項２４の空間光変調器であって、前記反射部材は、１つの共通の素子ピンを介して１つの電位に設定される空間光変調器。

【請求項２６】

請求項２３又は２４の空間光変調器であって、前記対向電極（３０）は、１つの共通の対向ピンを介して１つの電位に設定される空間光変調器。

【請求項２７】

請求項２３～２６の空間光変調器であって、前記反射部材は、すべて、実質的に同じ時間、アドレス状態にされる空間光変調器。

【請求項２８】

結像面に配置され、電磁放射に感応する加工物（６０）をパターンニングするための装置であって、以下、

対物面に向けて電磁放射を放出するソース（１１）と、

前記対物面において前記電磁放射を受け、この電磁放射を前記結像面に配置された前記加工物（６０）に向けて中継するように構成された、複数の反射素子を有するコンピュータ制御焦点板（３０）とを有し、

ここで、前記コンピュータ制御焦点板（３０）が複数の反射素子を有するものにおいて、前記反射素子は、請求項１～２３のいずれかの可動マイクロ素子であることを特徴とする装置。

【請求項２９】

表面から離間して配置された可動マイクロ素子の履歴効果を低減させるための方法であって、ここで前記表面が、少なくとも１つの電極を有するものにおいて、前記方法は以下の工程：

前記可動マイクロ素子を、非アドレス状態を形成する第２電位に設定する工程と、

アドレス電極を第１電位にアドレスする工程であって、ここで前記アドレス電極は、前記表面上に配置され、前記可動マイクロ素子を静電吸引可能である工程と、

前記可動マイクロ素子を、所定のパルス信号が発信される前の時間 $\Delta t$ において、前記第２電位から、アドレス状態を形成する第３電位に切り替える工程と、

前記可動マイクロ素子を、時間 $\Delta t + \Delta t'$ の間、前記アドレス状態に維持する工程とを包含する方法。

【請求項３０】

請求項２９の方法であって、更に、以下の工程：

前記第３電位から前記第２電位へ前記可動マイクロ素子を切り替えることによって、前記非アドレス状態に戻す工程を包含する方法。

【請求項３１】

請求項２９の方法であって、更に以下の工程：

前記可動マイクロ素子を、前記アドレス状態後に、静電非吸引状態に切り替える工程を包含する方法。

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## 【請求項 3 2】

請求項 3 1 の方法であって、更に以下の工程：

前記所定パルス信号によって、前記アドレス電極と、前記可動マイクロミラーとの間の電位差をクリアし、これにより、前記可動マイクロ素子を前記静電非吸引状態に復帰させる工程を包含する方法。

## 【請求項 3 3】

請求項 2 9 ～ 3 2 のいずれかの方法であって、前記所定パルス信号は、前記可動マイクロ素子に向けられる電磁放射信号である方法。

## 【請求項 3 4】

請求項 2 9 ～ 3 2 のいずれかの方法であって、前記所定パルス信号は、前記アドレス電極に接続されるとともに、前記第 1 電位をローディングされるコンデンサの放電を開始させることが可能な電気信号である方法。

## 【請求項 3 5】

請求項 2 9 ～ 3 4 のいずれかの方法であって、前記時間  $\Delta t + \Delta t'$  は、10 ms よりも短い方法。

## 【請求項 3 6】

請求項 2 9 ～ 3 4 のいずれかの方法であって、前記時間  $\Delta t + \Delta t'$  は、10  $\mu$ s よりも短い方法。

## 【請求項 3 7】

請求項 2 9 ～ 3 6 のいずれかの方法であって、前記第 2 電位の値は、前記アドレス電極に対してアドレスされる最大電位と最小電位との両方において非偏向状態を形成する、前記アドレス電極に対してアドレスされる最大電位の半分に実質的に等しく、前記第 3 電位は、前記アドレス電極に対してアドレスされる前記最小電位に実質的に等しい方法。

## 【請求項 3 8】

請求項 2 9 ～ 3 7 のいずれかの方法であって、更に以下の工程：

前記可動マイクロ素子を、その中間部分に沿って、捻れ軸心を形成する一対の捻りヒンジによって支持する工程を包含する方法。

## 【請求項 3 9】

請求項 2 9 ～ 3 7 のいずれかの方法であって、更に以下の工程：

前記可動マイクロ素子を、その中間部分に沿って、傾動軸心を形成する一対の回動部材によって支持する工程であって、ここで、前記復帰部材は、非偏向状態において前記可動マイクロ素子を復帰させるとともに、これと同時に、前記可動マイクロ素子が前記傾動軸心回りで傾動することを許容することが可能な少なくとも 1 つの屈曲ヒンジである工程を包含する方法。

## 【請求項 4 0】

請求項 3 8 ～ 3 9 のいずれかの方法であって、更に、以下の工程：

少なくとも 1 つの屈曲ヒンジによって前記可動マイクロ素子を復帰させる工程を包含する方法。

## 【請求項 4 1】

請求項 2 9 ～ 3 7 のいずれかの方法であって、更に、以下の工程：

前記可動マイクロ素子を、その中間部分の 1 つに沿って、前記可動マイクロ素子を弛緩状態に復帰させるとともに、これと同時に、前記可動マイクロ素子が前記少なくとも 1 つの電極を有する前記表面に対して垂直移動することを許容することが可能な一対の屈曲ヒンジによって支持する工程を包含する方法。

## 【請求項 4 2】

請求項 2 9 ～ 3 7 のいずれかの方法であって、更に、以下の工程：

前記可動マイクロ素子を、その中間部分の二つに沿って、前記可動マイクロ素子を弛緩状態に復帰させるとともに、これと同時に、前記可動マイクロ素子が、前記少なくとも 1 つの電極を有する前記表面に対して垂直移動することを許容することが可能な一対の屈曲ヒンジによって支持する工程を包含する方法。

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## 【請求項 4 3】

請求項 4 1 ~ 4 2 のいずれかの方法であって、前記屈曲ヒンジは、多角形の角部に取り付けられている方法。

## 【請求項 4 4】

請求項 4 1 ~ 4 2 のいずれかの方法であって、前記屈曲ヒンジは、多角形の面部に取り付けられている方法。

## 【請求項 4 5】

請求項 3 8 ~ 4 4 のいずれかの方法であって、前記屈曲ヒンジの少なくとも 1 つおよび／又は前記捻れ軸心の少なくとも 1 つは、曲折形状である方法。

## 【請求項 4 6】

請求項 2 9 ~ 4 5 のいずれかの方法であって、前記可動マイクロ素子は、請求項 1 ~ 2 3 のいずれかの可動マイクロ素子である方法。

## 【請求項 4 7】

請求項 2 9 ~ 4 6 のいずれかの方法であって、更に、以下の工程：

前記所定パルス信号を、前記時間  $\Delta t'$  が、前記所定信号のパルス長と実質的に等しくなるように、前記時間  $\Delta t + \Delta t'$  と同期させる工程を包含する方法。

## 【請求項 4 8】

請求項 2 9 の方法であって、更に、以下の工程：

前記パルス信号が前記可動マイクロ素子に到達することを阻止しながら累積履歴作用を中和化する工程を包含する方法。

## 【請求項 4 9】

請求項 4 8 の方法であって、前記中和化工程は、前記可動マイクロ素子が意図された作動中に偏向される状態に対してこれら個々の可動マイクロ素子を逆方向に偏向させることによって行われる方法。

## 【請求項 5 0】

請求項 4 9 の方法であって、個々の可動マイクロ素子は、前記累積時間及び第 2 偏向方向に於ける偏向の度合いに応じて、所与の時間及び所与の偏向度、第 1 方向に偏向される方法。

## 【請求項 5 1】

請求項 4 8 の方法であって、前記累積履歴作用の前記中和化は、加工物上の完全なパターンを構成する異なるストリップ間において行われる方法。

## 【請求項 5 2】

請求項 4 8 の方法であって、前記累積履歴作用の前記中和化は、少なくとも 1 つの可動マイクロ素子が所定の累積時間偏向された後に行われる方法。

## 【発明の詳細な説明】

## 【技術分野】

## 【0001】

本発明は、一般に機械部材におけるヒステリシス又は履歴効果を減少させるための技術、特に、可動マイクロ素子と、それにアドレスする方法とに関する。

## 【背景技術】

## 【0002】

好適なミラー偏向のために必要なアドレス電圧を変化させる原因となる空間光変調器 (SLM) におけるミラー偏向量のヒステリシス又は履歴は、それによってミラーの偏向の精度が低下するために、問題である。この変化は、そのミラーが偏向された時間、偏向量、及び、ミラーがその偏向後に弛緩する必要がある時間に依存する。これらの現象の時定数は、数分間／数時間の範囲であるので、マスクライター又は、最新の SLM 技術を使用した直接ライタにおける任意のパターンにおいて必要なアドレス電圧を予測し、それを補償することは事実上不可能である。

## 【0003】

履歴を補償することにおける問題点は、SLM のミラーには、データが、行毎に、常に同

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じ方向からロードされることにある。このことは、すべてのミラーが完全偏向状態にある時に、第1列の画素は、非常に高いデューティサイクルを有し、最後の行においては、それらは非常に低いデューティサイクルを有し、中間の行においては、中間のデューティサイクルを有するということを意味する。従って、これらのデューティサイクルを平均化するために、SLMを、二回目毎に、第1行及び最後の行からデータをロードするように再構成しない限り、履歴効果に対するバランスとして、集合的にアドレス可能な画素カウンタ電極を使用することも、不可能、又は、少なくとも非常に困難である。またそのように構成した場合でも、履歴は、依然としてパターン依存性であり、ミラーを頻繁に較正するか、もしくは、SLMのミラーを弛緩させるために、所定時間、そのシステムをアイドル状態に放置することが必要であろう。

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【0004】

従って、履歴効果の少ない、方法及び装置が当該分野において求められている。

【発明の開示】

【発明が解決しようとする課題】

【0005】

上記背景に鑑みて、可動マイクロ素子及び、SLMのミラー部材等の、個々の可動マイクロ素子にアドレスするための方法において、履歴効果を減少させることが非常に重要である。

【0006】

従って、本発明の課題は、上述した問題を解決する、又は、少なくとも軽減する、改良された可動マイクロ素子を提供することにある。

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【課題を解決するための手段】

【0007】

第1実施例において、本発明は、少なくとも1つの電極を有する表面から離間して配置されて、履歴効果又はヒステリシス効果の少ない、可動マイクロ素子を提供する。前記可動マイクロ素子には、少なくとも1つの復帰部材が接続されている。前記表面上にはアドレス電極が配設され、前記可動マイクロ素子を静電吸引可能である。前記アドレス電極は、第1電位にアドレスされる。前記可動マイクロ素子は、先ず、非アドレス状態を形成する第2電位に設定され、所定のパルス信号が発信される前の時間 $\Delta t$ において、前記可動マイクロ素子は、前記第2電位から、アドレス状態を形成する第3電位に切り替えられる。前記可動マイクロ素子は、時間 $\Delta t + \Delta t'$ の間、前記アドレス状態に維持される。

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【0008】

本発明の別実施例において、前記可動マイクロ素子は、前記第3電位を前記第2電位へ戻すことによって、前記アドレス状態後に、前記非アドレス状態に戻される。

【0009】

本発明の別実施例において、前記可動マイクロ素子は、前記アドレス状態後に、静電非吸引状態に切り替えられる。

【0010】

本発明の別実施例において、前記所定パルス信号は、前記アドレス電極と、前記可動マイクロ素子との間の電位差をクリア可能であり、これにより、前記可動マイクロ素子を前記静電非吸引状態に復帰させる。

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【0011】

本発明の別実施例において、前記所定信号は、前記可動マイクロ素子に向けられる電磁放射信号である。

【0012】

本発明の別実施例において、前記所定信号は、前記アドレス電極に接続されるとともに、前記第1電位をローディングされるコンデンサの放電を開始させることが可能な電気信号である。

【0013】

本発明の別実施例において、前記時間 $\Delta t + \Delta t'$ は、10msよりも短い。

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## 【0014】

本発明の別実施例において、前記時間  $\Delta t + \Delta t'$  は、 $10 \mu s$  よりも短い。

## 【0015】

本発明の別実施例において、前記第2電位の値は、前記アドレス電極に対してアドレスされる最大電位と最小電位との両方において非偏向状態を形成する、前記アドレス電極に対してアドレスされる最大電位の半分に実質的に等しく、前記第3電位は、前記アドレス電極に対してアドレスされる前記最小電位に実質的に等しい。

## 【0016】

本発明の更に別の実施例において、前記可動マイクロ素子は、その中間部分に沿って、捻れ軸心を形成する一対の捻りヒンジによって支持されている。

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## 【0017】

本発明の更に別の実施例において、前記可動マイクロ素子は、その中間部分に沿って、傾動軸心を形成する一対の回動部材によって支持され、前記復帰部材は、非偏向状態において前記可動マイクロ素子を復帰させるとともに、これと同時に、前記可動マイクロ素子が前記傾動軸心回りで傾動することを許容することが可能な少なくとも1つの屈曲ヒンジである。

## 【0018】

更に別の実施例において、本発明は、更に、非偏向位置において前記可動マイクロ素子を復帰させるとともに、これと同時に、前記可動マイクロ素子が前記傾動軸心回りで回転することを許容することが可能な少なくとも1つの屈曲ヒンジを有する。

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## 【0019】

本発明の更に別の実施例において、前記可動マイクロ素子は、その中間部分の1つに沿って、前記可動マイクロ素子を弛緩状態に復帰させるとともに、これと同時に、前記可動マイクロ素子が前記少なくとも1つの電極を有する前記表面に対して垂直移動することを許容することが可能な一対の屈曲ヒンジによって支持されている。

## 【0020】

本発明の更に別の実施例において、前記可動マイクロ素子は、その中間部分の二つに沿って、前記可動マイクロ素子を弛緩状態に復帰させるとともに、これと同時に、前記可動マイクロ素子が、前記少なくとも1つの電極を有する前記表面に対して垂直移動することを許容することが可能な二対の屈曲ヒンジによって支持されている。

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## 【0021】

本発明の更に別の実施例において、前記屈曲ヒンジは、多角形の角部に取り付けられている。

## 【0022】

本発明の更に別の実施例において、前記屈曲ヒンジは、多角形の面部に取り付けられている。

## 【0023】

本発明の更に別の実施例において、前記屈曲ヒンジの少なくとも1つおよび／又は前記捻れ軸心の少なくとも1つは、曲折形状である。

## 【0024】

本発明の更に別の実施例において、前記表面は、更に、前記アドレス電極から側方に離間した対向電極を有し、前記アドレス電極と前記対向電極とは、前記可動マイクロ素子を静電吸引可能である。

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## 【0025】

本発明の更に別の実施例において、前記所定パルス信号は、前記アドレス電極と前記対向電極との間の電位差をクリア可能であり、これによって、前記可動マイクロ素子を前記非アドレス状態へ復帰させる。

## 【0026】

本発明の更に別の実施例において、前記所定パルス信号は、前記アドレス電極と前記対向電極との間の電位差をクリア可能であり、これによって、前記可動マイクロ素子を静電非

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吸引状態へ復帰させる。

【0027】

本発明の更に別の実施例において、前記所定信号は、前記可動マイクロ素子に向けられる電磁放射である。

【0028】

本発明の更に別実施例において、前記所定信号は、前記アドレス電極に接続されるとともに、前記第1電位をローディングされるコンデンサの放電をすることが可能な電気信号である。

【0029】

本発明の更に別の実施例において、前記所定パルス信号は、前記時間 $\Delta t'$ が、前記所定信号のパルス長と実質的に等しくなるように、前記時間 $\Delta t + \Delta t'$ と同期される。

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【0030】

本発明は、更に、複数の反射部材を備える空間光変調器に関し、ここで、前記反射部材は、前記実施例のいずれかの可動マイクロ素子である。

【0031】

本発明の別の実施例において、前記反射部材は、1つの共通の素子ピンを介して1つの電位に設定される。

【0032】

本発明の更に別の実施例において、前記対向電極は、1つの共通の対向ピンを介して1つの電位に設定される。

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【0033】

本発明の更に別の実施例において、前記反射部材は、すべて、実質的に同じ時間、アドレス状態にされる。

【0034】

本発明は、更に、結像面に配置され、電磁放射に感応する加工物をパターンニングするための装置に関する。

【0035】

第1実施例において、本発明は、対物面に向けて電磁放射を放出するソースと、前記対物面において前記電磁放射を受け、この電磁放射を前記対物面に配置された前記加工物に向けて中継するように構成された、複数の反射可動マイクロ素子を有するコンピュータ制御焦点板とを提供し、ここで、前記コンピュータ制御焦点板が複数の反射マイクロ部材を有するものにおいて、前記反射マイクロ部材は、前記実施例のいずれかの可動マイクロ素子であることを特徴とする。

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【0036】

本発明は、更に、表面から離間して配置された可動マイクロ素子の履歴効果を低減させるための方法に関し、ここで、前記表面は、少なくとも1つの電極を有する。

【0037】

第1実施例において、本発明は、以下の工程を包含する、  
前記可動マイクロ素子を、非アドレス状態を形成する第2電位に設定する、  
アドレス電極を第1電位にアドレスする、ここでアドレス電極は、前記表面上に配置され、前記可動マイクロ素子を静電吸引可能である、  
前記可動マイクロ素子を、所定のパルス信号が発信される前の時間 $\Delta t$ において、前記第3電位から、アドレス状態を形成する第4電位に切り替える、  
前記可動マイクロ素子を、時間 $\Delta t + \Delta t'$ の間、前記アドレス状態に維持する。

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【0038】

別実施例において、本発明は、更に以下の工程を包含する、  
前記第3電位から前記第2電位へ前記可動マイクロ素子を切り替えることによって、前記非アドレス状態に戻す。

【0039】

別実施例において、本発明は、更に以下の工程を包含する、

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前記可動マイクロ素子を、前記アドレス状態後に、静電非吸引状態に切り替える。

【0040】

別実施例において、本発明は、更に以下の工程を包含する、  
前記所定パルス信号によって、前記アドレス電極と、前記可動マイクロ素子との間の電位差をクリアし、これにより、前記可動マイクロ素子を前記静電非吸引状態に復帰させる。

【0041】

本発明の別実施例において、前記所定信号は、前記可動マイクロ素子に向けられる電磁放射信号である。

【0042】

本発明の別実施例において、前記所定信号は、前記アドレス電極に接続されるとともに、前記第1電位をローディングされるコンデンサの放電を開始させることが可能な電気信号である。

【0043】

本発明の別実施例において、前記時間  $\Delta t + \Delta t'$  は、10msよりも短い。

【0044】

本発明の別実施例において、前記時間  $\Delta t + \Delta t'$  は、10 $\mu$ sよりも短い。

【0045】

本発明の別実施例において、前記第2電位は、前記アドレス電極に対してアドレスされる最大電位と最小電位との両方において非偏向状態を形成する、前記アドレス電極に対してアドレスされる最大電位の半分に実質的に等しく、前記第3電位は、前記アドレス電極に対してアドレスされる前記最小電位に実質的に等しい。

【0046】

更に別の実施例において、本発明は、更に以下の工程を包含する、  
前記可動マイクロ素子を、その中間部分に沿って、捻れ軸心を形成する一対の捻りヒンジによって支持する。

【0047】

更に別の実施例において、本発明は、更に以下の工程を包含する、  
前記可動マイクロ素子を、その中間部分に沿って、傾動軸心を形成する一対の回動部材によって支持する、ここで、前記復帰部材は、非偏向状態において前記可動マイクロ素子を復帰させるとともに、これと同時に、前記可動マイクロ素子が前記傾動軸心回りで回転することを許容することが可能な少なくとも1つの屈曲ヒンジである。

【0048】

更に別の実施例において、本発明は、更に、以下の工程を包含する、  
少なくとも1つの屈曲ヒンジによって前記可動マイクロ素子を復帰させる。

【0049】

更に別の実施例において、本発明は更に以下の工程を包含する、  
前記可動マイクロ素子を、その中間部分の1つに沿って、前記可動マイクロ素子を弛緩状態に復帰させるとともに、これと同時に、前記可動マイクロ素子が前記少なくとも1つの電極を有する前記表面に対して垂直移動することを許容することが可能な一対の屈曲ヒンジによって支持する。

【0050】

更に別の実施例において、本発明は、更に以下の工程を包含する、  
前記可動マイクロ素子を、その中間部分の二つに沿って、前記可動マイクロ素子を弛緩状態に復帰させるとともに、これと同時に、前記可動マイクロ素子が、前記少なくとも1つの電極を有する前記表面に対して垂直移動することを許容することが可能な一対の屈曲ヒンジによって支持する。

【0051】

本発明の別の実施例において、前記屈曲ヒンジは、多角形の角部に取り付けられている。

【0052】

本発明の別の実施例において、前記屈曲ヒンジは、多角形の面部に取り付けられている。

## 【0053】

更に別の実施例において、本発明は、更に以下の工程を包含する、前記屈曲ヒンジの少なくとも1つおよび／又は前記捻れ軸心の少なくとも1つは、曲折形状である。

## 【0054】

本発明の別の実施例において、前記可動マイクロ素子は、前記実施例のいずれかの可動マイクロ素子である。

## 【0055】

更に別の実施例において、本発明は、更に以下の工程を包含する、前記所定パルス信号を、前記時間 $\Delta t'$ が、前記所定信号のパルス長と実質的に等しくなるように、前記時間 $\Delta t + \Delta t'$ と同期させる。

## 【発明を実施するための最良の形態】

## 【0056】

本発明とその利点の更に完全な理解のために、添付図面を参照して以下の説明を参照する。

## 【0057】

図1aは、本発明による履歴効果が少ない、可動マイクロ素子、たとえば、マイクロ機械部材、の第1実施例を図示している。前記可動マイクロ素子は、たとえば、空間光変調器(Spatial Light Modulator: SLM)のミラーとすることができ、前記ミラーは、電気入力関数として該ミラー部材の偏向度を選択的に操作するべくアナログモードで、あるいは、最大偏向と非偏向とによって形成される該ミラー部材のON及びOFF状態を表すデジタルモードで作動可能である。前記ミラー部材の偏向は、このミラー(可動マイクロ素子)が、いかに物理的に作用されるかに応じて、前記入力信号関数として、ほぼ線形であってもよいし、非線形であってもよい。

## 【0058】

本実施例において、前記可動マイクロ素子10は、その1つの中間部分に沿って、一对の捻りヒンジ60によって支持されたほぼ矩形の反射部材である。この反射部材は、たとえば、多角形、円形、又は楕円形、等の任意の形状にすることができる。前記ヒンジは、それに沿って捻り軸心を形成する。前記捻りヒンジは、前記可動マイクロ素子10から延出して、支持部材50によって支持されている。この支持部材は、基材20上に支持されている。前記可動マイクロ素子10、前記捻りヒンジ60、前記支持部材50及び前記基材は、たとえば、ケイ素やアルミニウムなどの同じ材料から形成することができ、それらは、当業者にとって周知のエッチング技術を使用して1つの基材からエッチングすることができるので、それらについて更に説明することは不要である。

## 【0059】

前記基材は、更に、導電性アドレス電極40と、オプションとしての導電性対向電極30とを有する。これらアドレス電極40とオプションとしての対向電極30とは、前記基材20内に形成された下方のアドレス回路(図示せず)に接続されている。前記アドレス電極は、コンデンサに接続され、これらコンデンサは、前記電極に対してアドレスされるアドレス電圧を保持する。前記オプションの対向電極30とアドレス電極40とは、前記表面20上で互いに側方に離間され、前記可動マイクロ素子10を静電吸引可能である。前記捻りヒンジ60は、前記可動マイクロ素子10と共に回転又は捻れて、機械的エネルギーとしての復元力を提供する。前記可動マイクロ素子、前記オプションの対向電極30及びアドレス電極に対して電圧がかかっていない時は、前記可動マイクロ部材は、以下の説明において、電気的非吸引状態として記載される、通常フラットな又は非偏向位置にあるとされる。前記アドレス電圧をアドレス電極から対向電極にシフトすることによって、前記可動マイクロ素子は、反対方向に回動させることができる。

## 【0060】

図1bは、本発明による履歴効果が少ない、可動マイクロ素子の第2実施例を図示している。この第2実施例は、前記第1実施例に加えて、前記可動マイクロ素子10に接続され

るとともに、支持部材 50 によって支持された二つのフレキシブルヒンジ 70 を有する。これらフレキシブルヒンジ 70 も、前記可動マイクロ素子 10 が前記捻りヒンジ 60 によって形成される前記捻り軸心回りで偏向する時に、復元力を提供し、変形又は屈曲する。この実施例において、前記フレキシブルヒンジ 70 は、その端部の 1 つが前記支持部材 50 に接続され、その他端部が前記可動マイクロ素子 10 に接続された L 形状である。これらフレキシブルヒンジの一方は、前記捻りヒンジの一方と同じ側に接続され、他方のフレキシブルヒンジは、他方の捻りヒンジと同じ側に接続され、これらフレキシブルヒンジは、前記可動マイクロ素子上で対角線方向に互いに離間している。

#### 【0061】

図 1 c は、本発明による履歴効果の少ない、可動マイクロ素子の第 3 実施例を図示している。この実施例と前記第 2 実施例との相違点は、前記可動マイクロ素子 10 が、前記捻れヒンジ 60 の代わりに二つの枢支部 65 を有することにある。これら枢支部は、前記支持部材 50 によって支持されている。これら枢支部は、前記支持部材 50 の上部に形成された凹部 55 内に位置し、前記可動マイクロ素子 20 のその傾動軸心回りでの傾動のみを許容し、それがその位置から側方に外れて移動することは許容しないように、前記枢支部 65 のサイズに適合されている。

#### 【0062】

復元力は、前記可動マイクロ素子 10 が、前記枢支部 60 によって形成される前記傾動軸心回りで偏向するとき、変形または屈曲するフレキシブルヒンジ 70 によって提供される。この実施例において、前記フレキシブルヒンジ 70 は、その端部の 1 つが前記支持部材 50 に接続され、その他端部が前記可動マイクロ素子 10 に接続された L 形状である。これらフレキシブルヒンジの一方は、前記枢支部の一方と同じ側に接続され、他方のフレキシブルヒンジは、他方の枢支部と同じ側に接続され、これらフレキシブルヒンジは、前記可動マイクロ素子上で対角線方向に互いに離間している。

#### 【0063】

図 1 d は、本発明による履歴効果の少ない、可動マイクロ素子の第 4 実施例を図示している。この第 4 実施例と図 1-3 を参照して記載した前述の実施例との相違点は、可動マイクロ素子 10 が、少なくとも 1 つのアドレス電極 40 が取り付けられた表面 20 に対して垂直な方向に上下移動することにある。フレキシブルヒンジ 70 が、前記可動マイクロ素子 10 に接続されるとともに、支持部材 50 によって支持されている。前記フレキシブルヒンジ 70 は、復元力を提供し、前記可動マイクロ素子 10 が、前記表面 20 に対して実質的に垂直方向に上下移動する時に、変形又は屈曲する。この実施例において、前記フレキシブルヒンジ 70 は、その端部の 1 つが前記支持部材 50 に接続され、その別の端部が前記可動マイクロ素子 10 に接続された矩形形状である。前記フレキシブルヒンジは、前記矩形の可動マイクロ素子 10 の二つ対向面に取り付けられている。好ましくは、前記ヒンジは、前記可動マイクロ素子 10 の対称軸心の 1 つと一致している。別の実施例において、少なくとももう一对のフレキシブルヒンジ 70 が、前記可動マイクロ素子 10 に取り付けられ、これらは、この可動マイクロ素子 10 の別の対称軸と一致している。図 1 d の実施例において、前記アドレス電極 40 は、前記可動マイクロ素子 10 と実質的に同じサイズで同じ形状であるが、このアドレス電極の形状とサイズを、共に、前記可動マイクロ素子 10 と異なるものとすることも可能である。前記アドレス電極は、又、複数のアドレス電極 40 に分割することも可能である。他の可動マイクロ素子（同じ画素の）を弛緩位置に維持した状態で（可動マイクロ素子 10 とアドレス電極 40 との間に静電吸引力が無い状態）、可動マイクロ素子 10 を下方にシフトする（この部材に当たるべく使用される波長の  $1/4$  だけ）ことによって、破壊的干渉が達成される。

#### 【0064】

図 1 e は、本発明による、履歴効果の少ない、可動マイクロ素子の第 5 実施例を図示している。この第 5 実施例と前記第 4 実施例との相違点は、前記フレキシブルヒンジ 70 が L 形状であり、これらフレキシブル部材 70 の数が、2 ではなく 4 であり、更に、それらの各対が、対角対称軸心と実質的に一致していることにある。

【0065】

図2は、本発明による、履歴効果を低減させる方法の略流れ図を示している。

【0066】

第1工程110は、前記可動マイクロ素子10を第2電位に設定する工程を表している。前記第2電位は、たとえば、前記アドレス電極にアドレスされる最大電位の値の半分である電位とすることができる。前記第3電極は非アドレス状態を形成する。

【0067】

第2工程120は、アドレス電極40を第1電位にアドレスする工程を表している。前記第1電位は、最小電位と前記最大電位との間の任意の値にすることができ、ここで、前記最小電位は接地電位とすることができ前記最大電位はたとえば20Vとすることができる。前記アドレス電極40は、前記表面20上に配置され、前記可動マイクロ素子10を静電吸引可能である。

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【0068】

第3工程130は、前記可動マイクロ素子を、前記第2電位から、アドレス状態を形成する第3電位に切り替える工程を表している。この第3電位への切り替えは、所定のパルス信号が発信される前の時間 $\Delta t$ に行われる。前記第3電位は、たとえば、接地電位とすることができる。

【0069】

第4工程140は、前記可動マイクロ素子を、一実施例では10msよりも短く、別の実施例では10 $\mu$ sよりも短い、 $\Delta t + \Delta t'$ に等しい時間、前記アドレス状態に維持する工程を表している。 $\Delta t'$ は、たとえば、そのコンデンサのタイプとサイズとに応じて数 $\mu$ s又はそれ以下とされる、コンデンサを放電するための時間に対応したものとすることができる。 $\Delta t$ は、サブ秒の範囲の任意の値、より好ましくは、約10ms以下、最も好ましくは10 $\mu$ s以下の値に設定することができる。 $\Delta t$ は、通常、 $\Delta t'$ よりも長い、その反対の構成も適用可能である。前記所定信号は、たとえば、パルスレーザなどの、パルス電磁放射ビームとすることができる。 $\Delta t'$ は、一実施例において、前記パルス信号のパルス長と同期される。

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【0070】

前記時間 $\Delta t + \Delta t'$ 前記アドレス状態にされた後、前記可動マイクロ素子は、前記第2電位に戻されるか、もしくは、静電非吸引状態へ切り替えられる。

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【0071】

空間光変調器は、一次元列又は二次元アレイ状に配置された可動マイクロ素子のタイプとすることができる複数のミラーを備えることができる。前記SLMにおいて、すべての可動マイクロ素子、すなわち、ミラー表面は、1つの電圧面に接続することができ、入力ピンの1つ、所謂素子ピンにおいてこの平面にアドレスすることが可能である。同じことは、前記基材20上のすべての対向電極30にも当てはまる。すなわち、それらは、所謂対向ピンを使用して共にアドレス可能である。前記対向電極30が接地電位に維持されているとき、前記アドレス電極は、接地電位にアドレスされ、可動マイクロ素子は、前記第3又は第4電位のいずれかに設定され、アドレス電極と可動マイクロ素子との間の電位差は、対向電極と可動マイクロ素子との間の電位差に等しいので、可動マイクロ素子は偏向されない。しかしながら、その厚みによっては、可動マイクロ素子の両エッジ間に小さな下方への曲げ部を設けることも可能である。この曲げ部は、前記可動マイクロ素子の厚みを一定として、この可動マイクロ素子にかかる電圧の増加に伴って増加する。前記SLMのすべてのミラーは、前記第3電位から前記第4電位へ、すなわち、前記非アドレス状態から前記アドレス状態へ、実質的に同時に切り替えられる。SLMのすべてのミラーは、又、実質的に同じ時間( $\Delta t + \Delta t'$ )前記アドレス状態にあり、これによって、これらミラー部材の履歴効果を除去、又は少なくとも低減する。これらミラー部材がアドレス状態にある時間が短いほど、これらミラー部材はヒステリシス効果(履歴効果)によって影響される度合いが少ない。すなわち、ミラー部材がアドレス状態にある時間の割合として定義されるデューティサイクルが短いほど、前記ヒステリシス効果によるミラー部材への

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影響は少なくなる。ミラー部材は、前記アドレス状態に短時間留まるだけでなく、ミラー部材全部が、実質的に同じ時間、すなわち  $\Delta t + \Delta t'$  だけ、前記アドレス状態に留まるのである。

#### 【0072】

もしも可動マイクロ素子が 10 V に設定され対向電極が接地電位に維持されるならば、可動マイクロ素子 10 は、アドレス電極が最低電圧 0 V にアドレスされる場合と最大電圧 20 V とにアドレスされる場合との両方において、実質的に非偏向状態に留まることになる。これは、静電気力において電圧の符号は重要ではなく、それは常に吸引状態であるということ認識することによって理解することができる。アドレス電極と可動マイクロ素子との間の電位差の関数としての偏向の一例が図 3 に図示されている。図 3 において、可動部材は、ゼロ電位にあり、偏向度を交互に上下に動かして測定しながら、アドレス電極の電位が変化されている。この図において、可動マイクロ素子は、ある電位差（この例では 10 V）以下では実質的に非偏向状態であることが理解できる。可動マイクロ素子とアドレス電極との間の電磁力は、前記捻りヒンジ 60（単数又は複数）および／又はフレキシブルヒンジ 70 の機械的復元力によって反作用を受ける。可動マイクロ素子に取り付けられたこれら捻りヒンジおよび／又はフレキシブルヒンジのタイプと数とに応じて、アドレス電極と可動マイクロ素子との間の電位差の関数としての前記偏向は変化可能である。

#### 【0073】

このことは、回転部材に対して 10 V を使用して対応する回転部材を実質的に偏向させることなく、すべての画素（すなわち、回転部材）にアドレスすることが可能であるということの意味する。たとえば、前記可動マイクロ素子に向けられた前記電磁放射信号とすることができる、所定の信号の直前に、可動マイクロ素子に対する電圧が 0 ボルトにシフトすると、すべての可動マイクロ素子は、同時に前記所望偏向状態になる。前記電磁放射が可動マイクロ素子に当たると、基材上の前記アドレス電極に接続されたすべてのコンデンサが放電され、可動マイクロ素子は、即座に前記非偏向、電磁非吸引状態に戻る。このようにして、すべての可動マイクロ素子を偏向するデューティサイクルを、ミラー電圧のスイッチング時間に基づいて、非常に小さなものとして維持することができる。もしも、 $\Delta t + \Delta t'$  が 10 マイクロ秒に維持されるならば、前記パルス信号の周波数が 1000 Hz であるとする、完全偏向状態のデューティサイクルは 1 % になる。

#### 【0074】

前記アドレス電極が、前記最大又は最小（接地）電位にアドレスされ、可動マイクロ素子が最大電位の値の半分に設定され、対向電極が接地電位に維持された時、可動マイクロ素子は偏向されず、アドレスされない。最大電位と最小電位との間の各値の場合、可動マイクロ素子は偏向され、アドレスされない。最悪のケースは、アドレス電圧が最大値の値の半分である場合である。この場合、アドレス電極と可動マイクロ素子は共に 10 V であるため、それらの間に力は発生しない。次に、対向電極が 10 V に対応する力によって可動マイクロ素子を下方に引っ張る。しかしながら、幸運なことに、この偏向は、図 3 から理解されるように、可動マイクロ素子の非線形挙動により、比較的小さなものである。

#### 【0075】

図 4 は、電磁放射感応材の層によってコーティングされた加工物 60 をパターンニングするための装置 100 の実施例を図示している。この装置 100 は、電磁放射を放出するソース 11 と、第 1 レンズ系 50 と、コンピュータ制御焦点板 30 と、第 2 レンズ系 20 と、空間フィルタ 70 と、第 3 レンズ系 40 と、加工物 60 とを有する。

#### 【0076】

前記ソース 11 は、780 nm から約 20  $\mu$ m までとして定義される赤外線（IR）から、本出願においては、100 nm から、その放射が電磁放射として扱われることが可能な限りの低い波長の範囲として定義される極紫外線（EUV）までの波長範囲の放射線を放出可能である。このソース 11 は、放射線をパルス状又は連続状に放出する。連続放射線ソース 11 からの放出放射線は、この放射線ソース 11 と前記コンピュータ制御焦点板 30 との間の放射線経路に位置するシャッタによってパルス状放射線に形成することが可能

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である。一例として、前記放射線ソース 11 は、パルス出力 248 nm、パルス長約 10 ns、反復速度 1000 Hz の KrF エキシマレーザとすることができる。前記反復速度は、1000 Hz 以下であってもよいし、1000 Hz 以上であってもよい。前記第 2 レンズ系 20 は、単純なレンズ又は、複数のレンズのアセンブリとすることができる。この第 2 レンズ系 20 は、前記放射線ソース 11 から放出された放射線を、前記コンピュータ制御焦点板 30 の表面上に均一に分配する。

#### 【0077】

前記第 2 レンズ系 20 は、無限遠にその射出ひとみを有することができ、このことは、放射線の円錐の中央軸心が平行であるということの意味する。前記対物面は、前記コンピュータ制御焦点板 30 の位置と一致し、この実施例では、前記放射線円錐の中央軸心は、前記対物面において平行である。前記コンピュータ制御焦点板 30 は、空間光変調器 (SLM) とすることができる。この実施例では、この SLM は、前記加工物 60 全体をパターンニングするのに必要なすべての情報を単一の瞬間に有する。

#### 【0078】

空間光変調器 30 は、反射式又は透過式のものとすることができる。図 1 に図示された実施例において、前記 SLM は、反射式 SLM である。反射式空間光変調器は二つのタイプ、すなわち、偏向式と位相式、がある。これらの間の違いは、特にマイクロミラーの場合、小さなものに見えるかもしれないが、位相式 SLM は、破壊的干渉によって反射方向のビームを消すのに対して、偏向式 SLM の画素は、反射ビームが、結像レンズの口径を外れるように、反射ビームを片側に幾何学的に偏向させる。通常、偏向式 SLM のマイクロミラーは、位相式 SLM のマイクロミラーと比較して、マイクロミラーの表面がフラットである、弛緩した SLM の表面によって形成されるフラット位置からより大きく変位する。本発明によって行われるような超精密パターンニングのためには、位相式 SLM の方が偏向式 SLM よりも優れている。

#### 【0079】

第 1 に、位相式 SLM は、その表面のすべてのパーツ、更に、ヒンジ、支持ポストが、前記破壊的干渉に関与し、完全消衰を達成することが可能であるため、コントラストがより優れている。

#### 【0080】

第 2 に、放射線を片側に偏向することによって作用するシステムは、中間変更角度において光軸回りで対称に形成することが困難であり、焦点が変更された場合に機能不安定性が発生する虞がある。位相式 SLM は、マイクロ加工ミラー、所謂マイクロミラー、又は、支持基材上の連続ミラー面によって構築することができ、前記ミラー面は、電気信号を使用して変形することが可能である。

#### 【0081】

たとえば、前記連続ミラーは、静電電界によって制御される粘弾性層を使用することができ、特に数ナノメートル程度の変形で十分である非常に短い波長の場合には、電界又はその他の電氣的、磁氣的、又は熱的に制御される反射面によって変形される圧電固体ディスクを使用することも同様に可能である。本出願の以下の記載においては、静電制御マイクロミラーマトリクス（一次元又は二次元）を前提としているが、それらの変調メカニズムとして、LCD 結晶又は電気光学材料に基づく透過式又は反射式 SLM や、圧電式又は電気歪動作を使用したマイクロ機械式 SLM 等の、上述したようなその他の構成も可能である。

#### 【0082】

前記 SLM は、コンピュータからの別々の入力によって変調される出力放射線を発生するプログラマブル装置である。SLM は、コンピュータから供給されるデータに応答して、光輝又は暗画素の発生を通じてマスクの作用をシミュレートする。たとえば、位相式 SLM は、エッチングされた固体ミラーのアレイである。各マイクロミラー部材は、別の支持ポスト又は隣接するミラーのいずれかによって支持することが可能な、捻りヒンジによってケイ素基材の上方に懸架されている。これらのマイクロミラー部材の下方にアドレス電極

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が配置されている。1つのマイクロミラーは、対物面に1つの画素を表す。結像面の画素は、ここでは、マイクロミラーと同じ幾何学形状を有するものとして定義されるが、その光学系、すなわち、その光学系が拡大式であるか、それとも非拡大式であるのかに応じて、大きいか、小さいかによってそのサイズは異なったものとすることができる。

#### 【0083】

前記マイクロミラーとアドレス電極とは、コンデンサとして作用し、マイクロミラーに対する電圧に対して、アドレス電極に対して当てられる電圧によって、マイクロミラーを懸架している前記捻りヒンジを捻り、これによって、マイクロミラーが回転することを許容し、それによって位相差を作り出す。与えられる電圧に応じて、マイクロミラーの回転は、フラット位置から完全回転位置までのいずれの状態もとることができる。その辺の長さが約 $16\mu\text{m}$ の実質的に方形の表面を有する完全回転状態のマイクロミラーは、通常 $8\text{mRad}$ である。より一般的には、前記完全回転マイクロミラーは、回転軸心に対して平行なエッジでの測定で、使用される波長の $1/4$ 回転するか、若しくは、前記表面に対して垂直に移動するマイクロミラーの場合は、最大状態と最小状態との間の差は、前記マイクロミラーの表面に対して平行な測定で、使用される波長の $1/4$ である。

#### 【0084】

投影システム80は、この実施例において、前記第3レンズ系40と、空間フィルタ70と、前記第1レンズ系50とを有する。前記第3レンズ系40と、空間フィルタ70とは、協働で、一般にフーリエフィルタと呼ばれているものを形成する。

#### 【0085】

前記空間フィルタ70は、この実施例では、プレートに形成された穴である。この穴は、一次およびより高次の次数に回折される実質的にすべての回折次数を阻止するように寸法構成及び配置構成されており、たとえば、前記穴は、前記第3レンズ系40からの焦点距離位置に配置することができる。反射された放射線は、同時に前記第1レンズ系50のひとみ面としても作用する焦点面において第3レンズ系40によって集められる。前記穴は、SLM中のアドレスされたマイクロミラーの一次又はより高次の回折次数の光をカットアウトし、これに対して、非アドレスミラー表面からの放射線はこの穴を通過することができる。その結果、従来のリトグラフィと同様、加工物60上で強度変調された空間像が形成される。最適な画像コントラストのためには、すべての画素が変更されたSLMの回折パターンは、ゼロ次数の放射線無しで、一次及びそれより高次の回折次数の光のみを含むものであるべきである。

#### 【0086】

前記第1レンズ系50は、この実施例では、無限縁にその射出ひとみを有している。すなわち、加工物60の位置によって形成される結像面の放射線の円錐の中心軸心は平行である。

#### 【0087】

前記加工物60は、半導体デバイスやディスプレイパネル用のフォトマスクなどの、感光面を備えた基材とすることができる。それは、又、感光層によってコーティングされた半導体ウエハとすることも可能である。本発明は、半導体デバイスパターン、ディスプレイパネル、一体型光デバイス、及び電子相互接続構造の直接パターンニングのみに用途を有するものではないので、それは、セキュリティパターンニング等のその他のタイプのパターンニングにも利用可能である。ここでパターンニングという用語は、フォトレジスト、及び写真乳剤の露光のみならず、放射線又は熱によって起動されるアブレーション又は化学的プロセス等の他の放射線感応媒体（たとえば、ドライプロセスペーパー）に対する放射線の作用も意味する、広い意味に理解されるべきである。本発明は、又、加工されたウエハが、放射線によって再加工される、ウエハ修復にも利用可能である。

#### 【0088】

前記加工物60は、一定の速度で移動する移動ステージ上に配置することも可能である。この場合、前記電磁放射線は、前記コンピュータ制御焦点板30を照射し、加工物60の上に結像される各パルスが、その加工物60の異なる部分を照射する、パルス状電磁ソー

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ス11である。たとえばSLMとすることができ、前記コンピュータ制御焦点板30は、そのマイクロミラーの全アレイが、各パルスに対して加工物60上に正確な画像を形成するべく再構成可能に作動する。

#### 【0089】

最初に、CADレイアウトからの二値パターンが、SLMデータのデータセットに変換される。このデータがSLMに転送され、ここで、それに組み込まれた制御電子構造によって、多数のマイクロミラーが位置を変える。これにより、非偏向画素は、加工物上の明るい領域を表す。前記画像平面において前に定義された特定の画像画素の放射線の各円錐は、たとえば、単一のマイクロミラーとすることができ、前記コンピュータ制御焦点板30の1つの特定のオブジェクト画素に対応する。各マイクロミラーは、上述したように可動マイクロ素子タイプのものとすることができ、

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#### 【0090】

加工物60上のパターンは、多数のSLMスタンプ(stamps)によって形成される。これらのスタンプは、互いに部分的に重なり合ったものとすることができ、これらのスタンプは、ストリップ状に共にグループ化され、そこで、各ストリップは、少なくとも二つのスタンプを有し、マスク基材の全長、又はその一部をカバーする。ストリップ上の前記スタンプは、一次元の線、たとえば、スタンプの行又は列として配置される。

#### 【0091】

図5は、SLMスタンプ150が加工物60上に配置される方法の一例を図示している。この図において、加工物60は、SLMスタンプ150の線11, 12, 13, 14, 15, 16, 17, 18と、8つの列c1, c2, c3, c4, c5, c6, c7, c8によってカバーされている。実際には、加工物は、数千のSLMスタンプによってカバーされるが、明瞭化のために、8x8のみのパターンが図示されている。個々のスタンプは、多数の画素、通常は、数百万の画素を有する。ストリップは、完全な線、11, 12, 13, 14, 15, 16, 17, 18又はそのような線の一部とすることができ、前記放射線ソースが、加工物に対してその上にパターンを結像するべくSLMに対して放射線を放出しながら、加工物を載せる支持構造はストリップの方向、たとえば、線11, 12, 13, 14, 15, 16, 17, 18に沿って移動する。1つのストリップを完了すると、支持構造は、ストリップの方向に対して実質的に垂直な方向、そして、この方向のスタンプのサイズに実質的に等しい方向に移動する。

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#### 【0092】

履歴(imprinting)は、すべてのパラメータを偏向状態において一定に保ったときに、アクチュエータ/画素位置の漸進的に増大する変化として現れる、累積的材料作用である。更に、それは、アクチュエータが、十分な時間、非偏向状態に放置された時に、多少保存されて(cure out)現れる。履歴の蓄積と履歴の保存とは共に非線形な作用である。このように、所与の時点における位置は、その時点においてアクチュエータが受けている静電力のみならず、この特定のアクチュエータの偏向の履歴にも依存する。従って、アクチュエータのレスポンスは、ある時間後において不正確になる。すなわち、リトグラフィープロセスにおけるマスク上のフィーチャーのプレースメント精度が低下する。

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#### 【0093】

本発明の別実施例において、前記履歴は、完全に、又は少なくとも大幅に低減される。

#### 【0094】

加工物上に完全なパターンを加工する時間の間、二回のレーザ閃光間の時間よりも長く、その時にパターンが形成されない時間の間隔が存在するかもしれない。前記支持構造体が1つの完了したストリップの端部からもう一つのストリップの始めへ移動するのに必要な時間である戻りストローク中、レーザは、SLMを照射しない。この戻りストローク中は、SLM上のパターンは、マスク上の最終パターンに作用していない。従って、戻りストロークの時間中に、1つのストリップからもう一つのストリップへの前記累積的履歴作用を低減又は中和するのに望ましい任意の方法でSLMを作動させることが可能である。

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## 【0095】

加工物上に特定のパターンをプリントする時に、個々の画素の偏向時間とその偏向の程度を、各ストリップの間にモニタしてもよい。たとえば、戻りストローク中における履歴に対する反作用は、各アクチュエータを逆又は負の状態にシフトさせることによって達成することができる。これは、SLM中の各アクチュエータに対して、その前のストリップ（単数又は複数）の露光（単数又は複数）中に発生した履歴を正確に抑止する、振幅、アドレス時間、又は、振幅とアドレス時間のセットを使用することによって行うことができる。

## 【0096】

更に、各アクチュエータに関して発生した瞬間的な履歴作用をモニタし、その後それをキャンセルする、フィードバックシステムを使用することも可能である。これは、すべてのアクチュエータが同じ振幅にアドレスされる時に各アクチュエータからのコントラストを測定する、イン・システム（in-system）カメラに基づくモニタシステムを使用することによって行うことができる。測定は、コントラスト微分（derivative）がそのマスクライターシステムに於ける可能な最高値であるアクチュエータの集合的地址位置を使用して、各ストリップの直後に行われるべきである。その後、この測定からの情報を使用して、戻りストロークの残り部分中の履歴反作用アドレッシングのために振幅とアドレス時間を微調節することができる。

## 【0097】

履歴作用を低減又は取り消すための時間として戻りストロークを使用する代わりに、この取り消しまたは低減方法を、完全なパターンの加工中のいかなる時点において実行してもよい。たとえば、特定のアクチュエータが、所与の時間、アドレス状態であった所与の時点において画像形成プロセスを停止してもよく、その場合、偏向の量を考慮に入れてもよいし、又は入れなくてもよい。

## 【0098】

履歴の取り消しは、1つ以上の工程で行ってもよい。偏向時間と偏向度とに関する情報から、又は、たとえばCCDカメラによって撮られた画像から計算された、所与の時間間隔において個々のアクチュエータを無効にした後、履歴が取り消されたSLMから採られた画像から更なる微調節を行ってもよい。各SLM画素は所与の状態に設定され、この状態からの相違の程度によって、そのアクチュエータの更なる微調節、又は、個々の画素のためのアドレス機能における補償が行われる。

## 【0099】

このように、これまで、加工物をパターンニングするための装置の特定の実施例を開示してきたが、このような具体的言及が、特許請求の範囲に記載されていることを除いて、本発明の範囲に対する限定として見なされることは意図されていない。更に、これまで本発明を、その特定の実施例との関連において記載してきたが、当業者はその他の実施例にも想到するであろうと理解され、特許請求の範囲には、そのような改変構成がすべて含まれるものと意図される。

## 【図面の簡単な説明】

## 【0100】

【図1a】本発明による履歴効果が少ない、可動マイクロ素子の第1実施例を図示している。

【図1b】本発明による履歴効果が少ない、可動マイクロ素子の第2実施例を図示している。

【図1c】本発明による履歴効果が少ない、可動マイクロ素子の第3実施例を図示している。

【図1d】本発明による履歴効果が少ない、可動マイクロ素子の第4実施例を図示している。

【図1e】本発明による履歴効果が少ない、可動マイクロ素子の第5実施例を図示している。

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【図 2】本発明による履歴効果を低減させる方法の略流れ図を示している。

【図 3】アドレス電極と可動マイクロ素子との間の電位差の関数としての偏向の略図を示している。

【図 4】電磁放射感応材層によってコーティングされた基材をパターニングするための光学システムを図示している。

【図 5】加工物上の S L M スタンプの構成を図示している。

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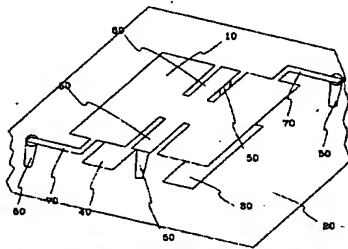
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(54) Title: A METHOD AND A DEVICE FOR REDUCING HYSTERESIS OR IMPRINTING IN A MOVABLE MICRO-ELE-  
MENT(57) Abstract: The present invention relates to a movable micro element with reduced imprinting or hysteresis effect arranged spaced apart from a surface comprising at least one electrode. At least one restoring element is connected to said movable micro element. An address electrode is arranged on said surface and capable to electrostatically attract said movable micro element. Said address electrode is addressed to a first potential. Said movable micro element is first set to a second potential defining a non addressed state and at a time period  $\Delta t_1$  before a predetermined pulsed signal is emitted said movable micro element is switched from said second potential to a third potential defining an addressed state. Said movable micro element is kept in said addressed state for a time period of  $\Delta t_2 + \Delta t_1$ . The invention also relates to a Spatial Light Modulator (SLM), an apparatus for patterning a workpiece and a method of reducing an imprinting or hysteresis effect of a movable micro element.

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A method and a device for reducing hysteresis or imprinting in a movable micro-element

#### TECHNICAL FIELD

5 The present invention relates in general to techniques for reducing hysteresis or imprinting effects in mechanical elements, and in particular to a movable micro-element and a method for addressing the same.

#### DESCRIPTION OF THE BACKGROUND ART

10 Hysteresis or imprinting of mirror deflection amplitude in Spatial Light Modulators (SLM), which leads to a shift in a required address voltage for a preferred mirror deflection, is a problem since it reduces the accuracy of the mirror deflection. This shift depends on an amount of time that the mirror has been deflected, an amplitude of the deflection and a  
15 time that the mirror has had to relax after said deflection. The time constants for these phenomena are in the region of minutes/hours making it virtually impossible to predict and compensate the required address voltages for an arbitrary pattern in a mask writer or a direct writer using a state of  
20 the art SLM technology.

A problem with a compensation for the imprinting is that the mirrors in the SLM are loaded with data row by row, always from the same direction. This means that with all mirrors in a fully  
25 deflected state the first row pixels will have a very high duty-cycle while in the last row they will have a very low duty-cycle and the intermediate rows will have intermediate duty-cycles. It is therefore also impossible, or at least very difficult, to use a collectively addressable pixel counter  
30 electrode as a balance for the imprinting effect unless the SLM is redesigned to load the data from the first and the last row every second time to average the duty-cycles. Even then the

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imprinting would still be pattern dependent and it would be necessary to often calibrate the mirrors or leave the system idle for a period of time to let the mirrors in the SLM relax.

- 5 Therefore, there is a need in the art for a method and an apparatus with reduced imprinting effect.

#### SUMMARY OF THE INVENTION

- 10 In view of the foregoing background, in the movable micro-elements and in the method for addressing individual movable micro-elements, such as for example mirror elements in a SLM, it is critical to reduce the imprinting effect.
- 15 Accordingly, it is an object of the present invention to provide an improved movable micro-element, which overcomes or at least reduces the above-mentioned problem.
- 20 In a first embodiment, the invention provides a movable micro-element with reduced imprinting effect or hysteresis effect arranged spaced apart from a surface comprising at least one electrode. At least one restoring element is connected to said movable micro-element. An address electrode is arranged on said surface and capable to electrostatically attract said movable
- 25 micro-element. Said address electrode is addressed to a first potential. Said movable micro-element is first set to a second potential defining a non addressed state and at a time period  $\Delta t$  before a predetermined pulsed signal is emitted said movable micro-element is switched from said second potential to
- 30 a third potential defining an addressed state. Said movable micro-element being in said addressed state for a time period of  $\Delta t + \Delta t'$ .

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In another embodiment of the invention said movable micro-element is switched back into said non addressed state after being in said addressed state by switching said third potential back to said second potential.

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In another embodiment of the invention said movable micro-element is switched into an electrostatically unattracted state after being in said addressed state.

10 In another embodiment of the invention said predetermined pulsed signal is capable to clear out a potential difference between said address electrode and said movable micro-element and thereby restoring said movable micro-element to said electrostatically unattracted state.

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In another embodiment of the invention said predetermined signal is an electromagnetic radiation signal directed onto said movable micro-element.

20 In another embodiment of the invention said predetermined signal is an electric signal which is capable to initiate a discharging of a capacitor connected to said address electrode and loaded with said first potential.

25 In another embodiment of the invention said time period  $\Delta t + \Delta t'$  is shorter than 10ms.

In another embodiment of the invention said time period  $\Delta t + \Delta t'$  is shorter than 10 $\mu$ s.

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In another embodiment of the invention a value of said second potential is essentially equal to half a maximum potential addressed to said address electrode defining an undeflected state at both the maximum and a minimum potential addressed to

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said address electrode and said third potential is essentially equal to the minimum potential addressed to said address electrode.

- 5 In still another embodiment of the invention said movable micro-element is supported along a mid-section by a pair of torsional hinges defining a torsional axis.

- 10 In still another embodiment of the invention said movable micro-element is supported along its mid section by a pair of pivot elements defining a tilting axis and where said restoring element is at least one flexure hinge capable of restoring said movable micro-element in an undeflected state but at the same time permitting said movable micro-element to tilt around said  
15 tilting axis.

- In still another embodiment, the invention further comprising at least one flexure hinge capable of restoring said movable micro-element in a undeflected position but at the same time  
20 permitting said movable micro-element to rotate around said tilting axis.

- In still another embodiment of the invention said movable micro-element is supported along one of its mid sections by a  
25 pair of flexure hinges capable of restoring said movable microelement to a relaxed state but at the same time permitting said movable micro-element to make an orthogonal movement with respect to said surface comprising said at least one electrode.

- 30 In still another embodiment of the invention said movable micro-element is supported along two of its mid sections by two pairs of flexure hinges capable of restoring said movable microelement to a relaxed state but at the same time permitting said movable micro-element to make an orthogonal movement with  
35 respect to said surface comprising said at least one electrode.

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In still another embodiment of the invention said flexure hinges are attached to the corners of a polygon.

5 In still another embodiment of the invention said flexure hinges are attached to the sides of a polygon.

10 In still another embodiment of the invention at least one of said flexure hinges and/or at least one of said torsional axis is meander shaped.

15 In still another embodiment of the invention said surface further comprising a counter electrode laterally spaced apart from said address electrode and where said address electrode and said counter electrode are capable to electrostatically attract said movable micro-element.

20 In still another embodiment of the invention said predetermined pulsed signal is capable to clear out a potential difference between said address electrode and said counter electrode and thereby restoring said movable micro-element to said non addressed state.

25 In still another embodiment of the invention said predetermined pulsed signal is capable to clear out a potential difference between said address electrode and said counter electrode and thereby restoring said movable micro-element to an electrostatically unattracted state.

30 In still another embodiment of the invention said predetermined signal is electromagnetic radiation directed onto said movable element.

35 In still another embodiment of the invention said predetermined signal is an electric signal capable of discharging a capacitor

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connected to said address electrode and loaded with said first potential.

5 In still another embodiment of the invention said predetermined pulsed signal is synchronised with said time period  $\Delta t + \Delta t'$  so that the time  $\Delta t'$  is essentially equal to the pulse length of said predetermined signal

10 The invention relates also to a spatial light modulator having a plurality of reflecting elements where said reflecting elements are movable micro-elements according to any one of the embodiments as described.

15 In another embodiment of the invention said reflecting elements are set to a potential via a common element pin.

In still another embodiment of the invention said counter electrodes are set to a potential via a common counter pin.

20 In still another embodiment of the invention all reflecting elements are in an addressed state for essentially the same period of time.

25 The invention relates also to an apparatus for patterning a workpiece arranged at an image plane and sensitive to electromagnetic radiation.

30 In a first embodiment, the invention provides a source emitting electromagnetic radiation directed onto an object plane. A computer controlled reticle comprising a plurality of reflecting movable micro-elements, adapted to receive said electromagnetic radiation at said object plane and to relay said electromagnetic radiation toward said work piece arranged said image plane, where said computer controlled reticle

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comprising a plurality of reflecting micro-elements characterized in that said reflecting micro-elements are movable micro-elements according to any one of the embodiments as described.

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The invention relates also to a method of reducing an imprinting effect of a movable micro-element arranged spaced apart from a surface, where said surface comprises at least one electrode.

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In a first embodiment, the invention comprising the actions of:

- setting said movable micro-element to a second potential defining a non addressed state,
- addressing an address electrode to a first potential, where address electrode is arranged on said surface and capable to electrostatically attract said movable micro-element,
- switching said movable micro-element from said third potential to a fourth potential, defining an addressed state, at a time  $\Delta t$  before a predetermined pulsed signal is emitted,
- keeping said movable micro-element in said addressed state for a time period of  $\Delta t + \Delta t'$ .

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In another embodiment, the invention further comprising the action of:

- switching said movable micro-element from said third potential back to said second potential thereby returning to said non addressed state.

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In another embodiment, the invention further comprising the action of:  
switching said movable micro-element into an electrostatically unattracted state after being in said addressed state.

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In another embodiment, the invention further comprising the action of:

- 5       - clearing out a potential difference between said address electrode and said movable micro-element by means of said predetermined pulsed signal and thereby restoring said movable micro-element to said electrostatically unattracted state.

- 10       In another embodiment of the invention said predetermined signal is an electromagnetic radiation signal directed onto said movable micro-element.

- 15       In another embodiment of the invention said predetermined signal is an electric signal capable to initiate a discharging of a capacitor connected to said address electrode and loaded with said first potential.

- 20       In another embodiment of the invention said time period  $\Delta t + \Delta t'$  is shorter than 10 ms.

In another embodiment of the invention said time period  $\Delta t + \Delta t'$  is shorter than 10  $\mu$ s.

- 25       In another embodiment of the invention said second potential is essentially equal to half a maximum potential addressed to said address electrode defining an undeflected state at both the maximum and a minimum potential addressed to said address electrode and said third potential is essentially equal to said minimum potential addressed to said address electrode.

- 30       In still another embodiment, the invention further comprising the action of:  
- supporting said movable micro-element along a mid section by a pair of torsional hinges defining a torsional axis.

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In still another embodiment, the invention further comprising the action of:

- supporting said movable micro-element along its mid section by a pair of pivot elements defining a tilting axis and where said restoring element is at least one flexure hinge capable of restoring said movable micro-element in an undeflected state but at the same time permitting said movable micro-element to rotate around said tilting axis.

In still another embodiment, the invention further comprising the action of:

- restoring said movable micro-element with at least one flexure hinge.

In still another embodiment, the invention further comprising the action of:

- supporting said movable micro-element along one of its mid sections by a pair of flexure hinges which are capable of restoring said movable micro-element to a relaxed state but at the same time permitting said movable micro-element to make an orthogonal movement with respect to said surface comprising said at least one electrode.

In still another embodiment, the invention further comprising the action of:

- supporting said movable micro-element along two mid sections by a pair of flexure hinges capable of restoring said movable micro-element to a relaxed state but at the same time permitting said movable micro-element to make an orthogonal movement with respect to said surface comprising said at least one electrode.

In another embodiment of the invention said flexure hinges are attached to the corners of a polygon.

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In another embodiment of the invention said flexure hinges are attached to the sides of a polygon.

- 5 In still another embodiment, the invention further comprising the action of:
- where at least one of said flexure hinges and/or at least one of said torsional axis is meander shaped.

- 10 In another embodiment of the invention said movable micro-element is a movable micro-element according to any one of the embodiments as described.

- 15 In still another embodiment, the invention further comprising the action of:
- synchronizing said predetermined pulsed signal with said time period  $\Delta t + \Delta t'$  so that the time  $\Delta t'$  is essentially equal to the pulse length of said predetermined signal.

#### BRIEF DESCRIPTION OF THE DRAWINGS

- 20 For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings, in which:

- 25 FIG. 1a shows a first embodiment of a movable micro-element with reduced imprinting effect according to the invention.

- 30 FIG. 1b shows a second embodiment of a movable micro-element with reduced imprinting effect according to the invention.

FIG. 1c shows a third embodiment of a movable micro-element with reduced imprinting effect according to the invention.

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FIG. 1d shows a fourth embodiment of a movable micro-element with reduced imprinting effect according to the invention.

5 FIG. 1e shows a fifth embodiment of a movable micro-element with reduced imprinting effect according to the invention.

FIG. 2 shows a schematic flow diagram of the method of reducing an imprinting effect according to the invention.

10 FIG. 3 shows a schematic diagram of the deflection as a function of potential difference between an address electrode and a movable micro-element.

15 FIG. 4 shows an optical system for patterning a substrate coated with a layer of electromagnetic radiation sensitive material.

FIG. 5 illustrates the arrangement of SLM stamps on the workpiece.

20 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1a shows a first embodiment of a movable micro-element, for example a micro mechanical element, with reduced imprinting effect according to the invention. Said movable micro-element  
25 may for example be a mirror in a Spatial Light Modulator (SLM). Said mirror may be operated in an analog mode to selectively steer the degree of deflection of said mirror element being a function of an electrical input or digital mode representing an ON and OFF state of the mirror element defined by maximum  
30 deflection and non deflection. The deflection of the mirror element may be generally linear or nonlinear, as a function of the input signal, depending on how said mirror (movable micro-element) is being mechanically affected.

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- In this embodiment the movable micro-element 10 is a generally rectangular reflective element supported along one its mid sections by a pair of torsion hinges 60. The reflective element may have any form for example polygonal, circular or elliptical.
- 5 Said hinges define a torsional axis there along. Said torsion hinges, extends from the movable micro-element 10 and is supported by a support element 50. The support element is supported upon a substrate 20. The movable micro-element 10, the torsion hinge 60, the support element 50 and the substrate may be of the same material for example silicon or aluminum and they
- 10 may be etched out of one substrate using well known etching techniques for a person skilled in the art and therefore does not need to be further described.
- 15 The substrate also comprises an electrically conducting address electrode 40 and an optional electrically conducting counter electrode 30. The address electrode 40 and the optional counter electrode 30 are connected to underlining address circuitry fabricated within the substrate 20 (not shown). The address
- 20 electrodes are connected to capacitors, which store the address voltage addressed to said electrode. The optional counter electrode 30 and the address electrode 40 are laterally spaced apart on said surface 20 and capable to electrostatically attract said movable micro-element 10. The torsion hinge 60,
- 25 rotate or twist with the movable micro-element 10 and provide restoring force in the form of mechanical energy. When no voltage is applied on the movable micro-element, the optional counter electrode 30 and the addressing electrode the movable micro-element is said to be in a normal flat or undeflected
- 30 position which herein below will be referred to as an electrically unattracted state. By shifting the address voltage from said address electrode to the counter electrode said movable micro-element can by rotated in an opposite direction.

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Figure 1b shows a second embodiment of a movable micro-element with reduced imprinting effect according to the invention. This second embodiment comprises in addition to the first embodiment two flexible hinges 70 connected to the movable micro-element 10 and supported by a support elements 50. Said flexible hinges 70 also provide restoring forces, and deform or flex, when the movable micro-element 10 deflects about the torsional axis defined by the torsion hinges 60. In this embodiment the flexible hinges 70 are L-shaped with one of its ends connected to the support elements 50 and another end connected to the movable micro-element 10. One of the flexible hinges is connected at the same side as one of the torsional hinges and the other flexible hinge is connected at the same side as the other torsion hinge and the flexible hinges are diagonally spaced apart on the movable micro-element.

Figure 1c shows a third embodiment of a movable micro-element with reduced imprinting effect according to the invention. This embodiment differs from the second embodiment in that the movable micro-element 10 comprises two pivots 65 instead of said torsion hinges 60. The pivots are supported by said support elements 50. Said pivots are lying in a recess 55 formed on top of said support 50 and adapted to the size of the pivot 65 in order to allow said movable micro-element 20 only to tilt around its tilting axis and not to move out sideways of its position.

Restoring forces are provided by flexible hinges 70 which deform or flex when the movable micro-element 10 deflects about the tilting axis defined by the pivots 60. In this embodiment the flexible hinges 70 are L-shaped with one of its ends connected to support elements 50 and another end connected to the movable micro-element 10. One of the flexible hinges is connected at the same side as one of the pivots and the other flexible hinge is connected at the same side as the other pivots and the flexible hinges are diagonally spaced apart on the movable micro-element.

Figure 1d shows a fourth embodiment of a movable micro-element with reduced imprinting effect according to the invention. This fourth embodiment differs from the previous embodiments as described in connection with figures 1-3 in that a movable micro-element 10 moves up and down in a direction perpendicular to a surface 20 on which at least one address electrode 40 is attached. Flexible hinges 70 are connected to the movable micro-element 10 and supported by support elements 50. Said flexible hinges 70 provide restoring forces, and deform or flex, when the movable micro-element 10 moves up and down in a direction essentially orthogonal to the surface 20. In this embodiment the flexible hinges 70 are rectangular with one of its ends connected to the support elements 50 and another end connected to the movable micro-element 10. The flexible hinges are attached to the rectangular movable micro-element on two opposite sides. Preferably said hinges coincide with one of the symmetry axis of said movable micro-element 10. In another embodiment at least another pair of flexible hinges 70 are attached to said movable micro-element 10 which coincide with another symmetry axis of said movable micro-element 10. In the embodiment in figure 1d the address electrode 40 is essentially of the same size and shape as the movable micro-element 10, alternatively both the shape and size of said address electrode 40 may be different to said movable micro-element 10. Said address electrode may also be split into a plurality of address electrodes 40. Destructive interference is achieved by shifting a movable micro-element 10 downwards (for one quarter of the wavelength used to impinge on said element) while another movable micro-element (in the same pixel) remains in a relaxed position (no electrostatically attraction force between the movable micro-element 10 and the address electrode 40).

Figure 1e shows a fifth embodiment of a movable micro-element with reduced imprinting effect according to the invention. This

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fourth embodiment differs from the fourth embodiment in that the flexible hinges 70 are L-shaped, the number of flexible elements 70 is four instead of two and in that each pair of them coincides essentially with a diagonal symmetry axis.

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Figure 2 shows a schematic flow diagram of the method of reducing an imprinting effect according to the invention.

10 A first action 110 represents setting said movable micro-element 10 to a second potential. Said second potential may for example be a potential which is half the value of a maximum potential addressed to the address electrode. The third potential defining a non addressed state.

15

A second action 120 represents addressing an address electrode 40 to a first potential. Said first potential may be any value between a minimum potential and the maximum potential, where said minimum potential may be a ground potential and said maximum potential may for example be 20 V. Said address electrode 40 is arranged on the surface 20 and capable to electrostatically attract said movable micro-element 10.

20

A third action 130 represents switching said movable micro-element from said second potential to a third potential, which defines an addressed state. The switching to said third potential takes place a time  $\Delta t$  before a predetermined pulsed signal is emitted. The third potential may for example be ground.

25

30 A fourth action 140 represents keeping the movable micro-element in said addressed state for a time period equal to  $\Delta t + \Delta t'$ , which in one embodiment is shorter than 10ms and in another embodiment shorter than 10 $\mu$ s.  $\Delta t'$  may for instance correspond to the time

period for discharging a capacitor which will be a few  $\mu$ s or shorter depending of the type and size of the capacitor.  $\Delta t$  can be set at any value in a sub second range, more preferably, approximately below 10ms, and most preferably below 10 $\mu$ s.  $\Delta t$  is typically longer than  $\Delta t'$  but the reverse may be applicable. The predetermined signal may for instance be a beam of a pulsed electromagnetic radiation such as for example a pulsed laser.  $\Delta t'$  is in one embodiment synchronized with the pulse length of the pulsed signal.

After being in said addressed state for the time period of  $\Delta t + \Delta t'$  the movable microelement is either switched back to the second potential or switched to an electrostatically unattracted state.

A Spatial Light Modulator may comprise a plurality of mirrors which may be of the type of movable micro-elements arranged in a one-dimensional row or a two dimensional array. In said SLM may all movable micro-element, i.e. mirror surfaces, be connected together to one voltage plane and it is possible to address this plane at one of the input pins, a so-called element pin. The same applies for all counter electrodes 30 on said substrate 20, i.e. they are jointly addressable using a so-called counter pin. When the counter electrode 30 is kept at the ground potential, the address electrode is addressed to ground potential and the movable micro-element is set either to the third or fourth potential the movable micro-element is not deflected since the potential difference between the address electrode and the movable micro-element is equal to the potential difference between the counter electrode and the movable micro-element. Depending on the thickness there may however be a small bending downwards in both edges of the movable micro-element. Said bending will increase with increased voltage applied on said movable micro-element for a constant thickness of the movable

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micro-element. All mirrors in the SLM are switched essentially at the same time from said third potential to said fourth potential, i.e. from said non addressed state to said addressed state. All mirrors in the SLM are also in said addressed state

5 essentially the same period of time ( $\Delta t + \Delta t'$ ) thereby eliminating or at least reducing the imprinting effect of the mirror elements. The shorter the time period the mirror elements are in the addressed state the less the mirror elements will be affected by the hysteresis effect (imprinting effect), i.e. a

10 shorter duty-cycle, defined as the percentage of time the mirror elements are in an addressed state, will result in less affected mirror elements by said hysteresis effect. The mirror elements are not only in said addressed state for a short time but each and every mirror element are in said addressed state essentially

15 the same time period namely  $\Delta t + \Delta t'$ .

If the movable micro-element is set at 10 V and the counter electrode is kept at ground potential the movable micro-element

10 will remain essentially undeflected both for the case that the address electrode is addressed to the minimum voltage 0 V and maximum voltage 20 V. This can be understood by realizing that the sign of the voltage is of no importance for the electrostatic force, it is always attractive. An example of the deflection as a function of the potential difference between the

20 address electrode and the movable micro-element is shown in figure 3. In figure 3 the movable element is at zero potential and the potential on the address electrode is varying while measuring the degree of deflection alternative up and down movement. In this figure one can see that the movable micro-

25 element is essentially undeflected below a certain potential difference, in this case 10 V. The electrostatic force between the movable micro-element and the address electrode is counteracted by the mechanical restoring force in the torsional hinge(s) 60 and/or the flexible hinge 70. Depending on the type

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and number of torsional hinges and/or flexible hinges attached to the movable micro-element said deflection as a function of the potential difference between the address electrode and the movable micro-element may change.

5

This means that it is possible to address all pixels, i.e. rotating elements, without essentially deflecting the corresponding rotating element using 10 V on the rotating elements. When the voltage on the movable micro-elements is shifted to 0 V just before a predetermined signal, which may for example be said electromagnetic radiation signal directed onto said movable micro-element, then all movable micro-elements will take the desired deflection simultaneously. When the electromagnetic radiation impinges on the movable micro-element all capacitors connected to the address electrodes on the substrate will be discharged and the movable micro-elements will immediately return to the undeflected and electrostatically unattracted state. In this way the duty-cycle for deflecting any movable micro-element can be kept very small depending on the switch time of the mirror voltage. If  $\Delta t - \Delta t'$  is kept at 10 microseconds, then the duty-cycle for fully deflected state will be 1% if a frequency of the pulsed signal is 1000 Hz.

When the address electrode is addressed to the maximum or minimum (ground) potential and the movable micro-element is set to half the value of the maximum potential and the counter electrode is kept at ground potential the movable micro-element is undeflected and unaddressed. For each value between said maximum and minimum potential said movable micro-element will be deflected and unaddressed. The worst case is an address voltage being half the value of the maximum value. In this case there is no force between the address electrode and the movable micro-element since they are both at 10 V. The counter electrode is then pulling the movable micro-element down with a force corresponding to 10 V. This deflection is fortunately however

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relatively small due to the non-linear behavior of the movable micro-element as can be seen from figure 3.

Figure 4 shows an embodiment of an apparatus 100 for patterning a work piece 60 coated with a layer of an electromagnetic radiation sensitive material. Said apparatus 100 comprises a source 11 for emitting electromagnetic radiation, a first lens arrangement 50, a computer controlled reticle 30, a second lens arrangement 20, a spatial filter 70, a third lens arrangement 40 and a work piece 60.

The source 11 may emit radiation in the range of wavelengths from infrared (IR), which is defined as 780 nm up to about 20  $\mu\text{m}$ , to extreme ultraviolet (EUV), which in this application is defined as the range from 100nm and down as far as the radiation is possible to be treated as electromagnetic radiation. The source 11 emits radiation either pulsed or continuously. The emitted radiation from the continuous radiation source 11 can be formed into a pulsed radiation by means of a shutter located in the radiation path between said radiation source 11 and said computer controlled reticle 30. As an example can the radiation source 11 be a KrF excimer laser with a pulsed output at 248 nm, a pulse length of approximately 10 ns and a repetition rate of 1000 Hz. The repetition rate may be below or above 1000 Hz. The second lens arrangement 20 may be a simple lens or an assembly of lenses. The second lens arrangement 20 distributes the radiation emitted from the radiation source 11 uniformly over a surface of the computer controlled reticle 30.

The second lens arrangement 20 may have its exit pupil at infinity, which means that central axis of cones of radiation are parallel. Said object plane coincides with the position of the computer-controlled reticle 30 and in this embodiment said central axis of cones of radiation are parallel in said object plane. The computer-controlled reticle 30 may be a Spatial Light

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Modulator (SLM). In this embodiment the SLM comprises all information at a single moment that is required to pattern the whole workpiece 60.

5 Spatial light modulators 30 may be based on reflection or transmission. In the embodiment as shown in figure 1 the SLM is a reflective SLM. Reflective Spatial Light modulators come in two varieties, the deflection type and the phase type. The differences between them may in a particular case with  
10 micromirrors seem small, but the phase SLM extinguishes the beam in the specular direction by destructive interference, while a pixel in a deflection SLM deflects the specular beam geometrically to one side so that it misses the aperture of the imaging lens. Typically, the micromirrors in a deflection SLM  
15 move more out of a flat position defined by the surface of a relaxed SLM, where the surface of the micromirrors is flat, compared to the micromirrors in a phase SLM. For ultra precise patterning as performed in the current invention the phase SLM is superior to the deflecting type.

20 First, it has better contrast since all parts of the surface, also hinges and support posts, take part in the destructive interference and total extinction can be achieved.

25 Second, a system that works by deflecting the radiation to the side is difficult to make symmetric around an optical axis at intermediate deflection angles, creating a risk of feature instability when focus is changed. The phase SLM can be built with micro machined mirrors, so called micromirrors, or with a  
30 continuous mirror surface on a supporting substrate, where said mirror surface is possible to deform by using an electronic signal.

For example, said continuous mirror may use a visco elastic  
35 layer controlled by an electrostatic field, but it is equally

possible, especially for very short wavelengths where deformations of the order of a few nanometers are sufficient, to use a piezoelectric solid disk that is deformed by electric field or another electrically, magnetically or thermally controlled reflecting surface. For the remainder of this application an electrostatically controlled micro-mirror matrix (one- or two dimensional) is assumed, although other arrangements as described above are possible, such as transmissive or reflective SLMs relying on LCD crystals or electro optical materials as their modulation mechanism, or micro-mechanical SLMs using piezoelectric or electrostrictive actuation.

The SLM is a programmable device that produces an output radiation beam that is modulated by separate inputs from a computer. The SLM simulates the function of a mask through the generation of bright and dark pixels in response to computer fed data. For example the phase SLM is an array of etched solid-state mirrors. Each micro-mirror element is suspended above a silicon substrate by torsion hinges, which may be supported either by separate support posts or by the adjacent mirrors. Beneath the micro-mirror element are address electrodes. One micro-mirror represents one pixel in the object plane. The pixel in the image plane is here defined as to have the same geometry as the micro-mirror but the size may be different due to the optics, i.e. larger or smaller depending on if the optics is magnifying or de-magnifying.

The micro-mirror and the address electrodes act as a capacitor so that a voltage applied to the address electrode, with respect to a voltage to the micro-mirror, will twist the torsion hinges suspending the micro-mirror which in turn allow the micro-mirror to rotate, thereby creating a phase difference. Depending on the voltage applied the rotation of the micro-mirror may take any state between flat to fully rotated position. A fully rotated

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- micro mirror having an essentially square surface with its sides approximately  $16\mu\text{m}$  long is typically  $8\text{mRad}$ . More generally the fully rotated micro-mirror will rotate one quarter of the wavelength used, measured at the edges parallel to the rotation axis or with micromirrors with orthogonal movement with respect to the surface the difference between max and min state is one quarter of the wavelength used, measured parallel with a surface of said micro-mirror.
- 10 A projection system 80 comprises in this embodiment the third lens arrangement 40, a spatial filter 70 and the first lens arrangement 50. The third lens arrangement 40 and the spatial filter 70 forms together what is generally called a Fourier filter.
- 15 The spatial filter 70 is in this embodiment an aperture in a plate. Said aperture being sized and positioned so as to block out essentially every diffraction order which is diffracted into the first and higher diffraction orders, for example said
- 20 aperture may be located at the focal distance from the third lens arrangement 40. The reflected radiation is collected by said third lens arrangement 40 in the focal plane, which acts at the same time as a pupil plane of the first lens arrangement 50. The aperture cuts out the light from the first and higher
- 25 diffraction orders of the addressed micromirrors in the SLM, while the radiation from the non-addressed mirror surfaces can pass the aperture. The result is intensity modulated aerial image on the work piece 60 as in conventional lithography. For an optimum image contrast the diffraction pattern of an SLM with
- 30 all pixels deflected should only contain light in the first and higher diffraction orders without any radiation in the zeroth order.
- The first lens arrangement 50 has in this embodiment its exit
- 35 pupil at infinity, i.e. central axis of cones of radiation in a

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image plane defined by the position of the work piece 60 are parallel.

- 5 The work piece 60 may be a substrate with a photosensitive surface, such as a photo mask for semiconductor devices and display panels. It may also be semi-conducting wafer coated with a photosensitive layer. Since the present invention not only have applications in direct patterning of semiconductor device patterns, display panels, integrated optical devices and electronic interconnect structures, it can also have
- 10 applications to other types of patterning such as security patterning. The term patterning should be understood in a broad sense, meaning exposure of photo resist and photographic emulsion, but also the action of radiation on other radiation sensitive media such as dry process paper, by ablation or chemical processes activated by radiation or heat. The present invention may also find application in wafer repairing, wherein a processed wafer is reprocessed with the radiation beam.
- 20 The work piece 60 may also rest on a moving stage, which moves at a constant velocity. The electromagnetic radiation is in said case a pulsed electromagnetic source 11 where each pulse that illuminates the computer controlled reticle 30 and is imaged onto the work piece 60 will illuminate a different part of the
- 25 work piece 60. The computer-controlled reticle 30 which for example may be a SLM operates so that the entire array of micromirrors can be reconfigured for each pulse to form the correct image on the work piece 60.
- 30 At first, binary pattern from a CAD layout is transformed into a data set of SLM data. The data is transferred to the SLM, where the built in control electronics causes a number of micromirrors to change position. Thereby, the non-deflected pixels represent bright regions on the work piece. Every cone of radiation in a
- 35 specific image pixel as defined previously in said image plane

corresponds to a specific object pixel in said computer controlled reticle 30, which for example may be a single micromirror. Each micromirror may be of the type of movable micro-element as described hereinabove.

5 A pattern on a work piece 60 is created by a number of SLM stamps. Said stamps may be partially overlapping each other. Said stamps may be grouped together in strips, where each strip comprises at least two stamps and covers the full length of a mask substrate or a portion of it. Said stamps in a strip are  
10 arranged in a one-dimensional line, for example a row or a column of stamps.

Figure 5 illustrates an example of how SLM stamps 150 are  
15 arranged on a workpiece 60. In said figure the workpiece 60 is covered by 8 lines 11, 12, 13, 14, 15, 16, 17, 18 and 8 columns c1, c2, c3, c4, c5, c6, c7, c8 of SLM stamps 150. In reality a workpiece is covered with several thousands of SLM stamps but for reason of clarity only an 8x8 pattern is illustrated. An  
20 individual stamp comprises a large number of pixels, typically in the order of million pixels. A strip may be a complete line 11, 12, 13, 14, 15, 16, 17, 18 or a portion of such a line. A support structure, which carries the workpiece, is moving along a direction of a strip, for example along a line 11, 12, 13, 14,  
25 15, 16, 17, 18 while the radiation source flashes radiation onto the SLM for imaging the pattern thereon to the workpiece. After having finished a strip, the support structure is moved in a direction essentially perpendicular to the direction of a strip and a distance essentially equal to a size of a stamp in said  
30 direction.

Imprinting is a cumulative material effect, which manifest itself by a gradually increased change of the actuator/pixel position when all parameters are kept constant in the deflected  
35 state. It further manifests itself by more or less curing out

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when the actuator is left in the non-deflected state for a sufficient amount of time. Both building up imprinting and curing out imprinting are non-linear effects. The position at a given time thus depends not only on the electrostatic force the actuator is experiencing at that time, but also on the history of deflection of this particular actuator. Therefore, the response of the actuator becomes inaccurate after a given period of time, i.e. the placement accuracy of features on the mask in the lithography process is reduced.

In another embodiment according to the invention said imprinting is completely or at least substantially reduced.

During the time period of processing a complete pattern on a workpiece, there may be time intervals, which are longer than the time between two laser flashes, when no pattern is generated. During the return stroke, which is the time it takes for the support structure to move from an end of a finished strip to a beginning of another strip, the laser does not illuminate the SLM. During the return stroke the pattern on the SLM is not affecting the final pattern on the mask. It is therefore possible to operate the SLM in any way desired to reduce or neutralize the cumulative imprinting effect from stripe to stripe during the time of a return stroke.

When printing a specific pattern on a work piece the time of deflection and the degree of deflection for each individual pixel may be monitored during each strip. Counteraction of imprinting during for example the return stroke can be achieved by shifting each actuator in a reversed or negative state. This may be done using amplitude and address time, or a set of amplitudes and address times, individually for each actuator in the SLM, which exactly inhibits the imprinting induced during the previous strip(s) exposure(s).

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It is further possible to use a feed back system in which the momentaneous imprinting induced for each actuator is monitored and thereafter cancelled. This can be done using an in-system camera based monitor system, where the contrast from each actuator is measured when all actuators are addressed to an identical amplitude. The measurements should be done immediately after each strip using a collective address position for the actuators where the contrast derivative is highest possible in the mask writer system. The information from this measurement can then be used to fine tune the amplitude and address time for the imprinting counteraction addressing during the rest of the return stroke.

Instead of using the return stroke as the time period for reducing or canceling the imprinting effects, said cancellation or reduction method may be performed at any time in the processing of a complete pattern. For instance, the imaging procedure may be stopped at any given time when a particular actuator has been in the addressed state for a given time period, where the amount of deflection may or may not be taken into account.

The cancellation of imprinting may be performed in more than one step. After having counteracted the individual actuators for a given time interval, either calculated from information about deflecting time and degree of deflection or from a picture taken by a CCD camera for example, a further fine tuning may be performed out of a picture taken of the imprinting cancelled SLM. Every SLM pixel is set to a given state, and the degree of difference from said state give rise to a further fine adjustment of said actuator or compensation in an addressing function for the individual pixels.

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Thus, although there has been disclosed to this point particular embodiments of the apparatus for patterning a work piece, it is not intended that such specific references be considered as limitations upon the scope of this invention except in-so-far as set forth in the following claims.

5 Furthermore, having described the invention in connection with certain specific embodiments thereof, it is to be understood that further modifications may suggest themselves to those skilled in the art, it is intended to cover all such

10 modifications as fall within the scope of the appended claims.

## CLAIMS

1. A movable micro-element (10) with reduced imprinting effect  
arranged spaced apart from a surface (20) comprising at  
least one electrode, at least one restoring element (60, 70)  
is connected to said movable micro-element (10), an address  
electrode (40) is arranged on said surface (20) and capable  
to electrostatically attract said movable micro-element (10)  
and where said address electrode (40) is addressed to a  
first potential, characterized in that said movable micro-  
element (10) is first set to a second potential defining a  
non addressed state and at a time period  $\Delta t$  before a  
predetermined pulsed signal is emitted onto said movable  
micro-element (10) is switched from said second potential to  
a third potential defining an addressed state, where said  
movable micro-element (10) is kept in said addressed state  
for a time period of  $\Delta t + \Delta t'$ .
2. The movable micro-element (10) according to claim 1, wherein  
said movable micro-element (10) is switched back into said  
non addressed state after being in said addressed state by  
switching said third potential back to said second  
potential.
3. The movable micro-element (10) according to claim 1, wherein  
said movable micro-element (10) is switched into an  
electrostatically unattracted state after being in said  
second potential.
4. The movable micro-element (10) according to claim 3, wherein  
said predetermined pulsed signal is capable to clear out a  
potential difference between said address electrode (40) and  
said movable micro-element (10) and thereby restoring said  
movable micro-element (10) to said electrostatically  
unattracted state.

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5. The movable micro-element (10) according to claim 1 or 4, wherein said predetermined pulsed signal is electromagnetic radiation directed onto said movable micro-element (10).
6. The movable micro-element (10) according to claim 1 or 4, wherein said predetermined pulsed signal is an electric signal capable to initiate a discharging of a capacitor connected to said address electrode (40) and loaded with said first potential.
7. The movable micro-element (10) according to any one of the preceding claims, wherein said time period  $\Delta t + \Delta t'$  is shorter than 10ms.
8. The movable micro-element (10) according to any one of claim 1-6, wherein said time period  $\Delta t + \Delta t'$  is shorter than 10 $\mu$ s.
9. The movable micro-element (10) according to claim 1, wherein a value of said second potential is essentially equal to half a maximum potential addressed to said address electrode (40) defining an undeflected state at both the maximum and a minimum potential addressed to said address electrode (40) and said third potential is essentially equal to said minimum potential addressed to said address electrode (40).
10. The movable micro-element (10) according to any one of claim 1-9, wherein said movable micro-element (10) is supported along a mid section by a pair of torsion hinges (60) defining a torsional axis.
11. The movable micro-element (10) according to any one of claim 1-9, wherein said movable micro-element (10) is supported along a mid section by a pair of pivot elements (65) defining a tilting axis and where said restoring element is at least one flexure hinge (70) capable of restoring said movable micro-element (10) in an undeflected state but at the same time permitting said movable micro-element (10) to tilt around said tilting axis.
12. The movable micro-element according to claim 10, further comprising at least one flexure hinge capable of restoring

said movable micro-element in an undeflected state but at the same time permitting said movable micro-element (10) to tilt around said tilting or torsional axis.

13. The movable micro-element (10) according to any one of claim 1-9, wherein said movable micro-element (10) is supported along one of its mid sections by a pair of flexure hinges (70) capable of restoring said movable micro-element (10) to a relaxed state but at the same time permitting said movable micro-element (10) to make an orthogonal movement with respect to said surface (20) comprising said at least one electrode.
14. The movable micro-element (10) according to any one of claim 1-9, wherein said movable micro-element (10) is supported along two mid sections by two pairs of flexure hinges (70) capable of restoring said movable micro-element (10) to a relaxed state but at the same time permitting said movable micro-element (10) to make an orthogonal movement with respect to said surface (20) comprising said at least one electrode.
15. The movable micro-element (10) according to any one of claim 13 or 14, wherein said flexure hinges (70) are attached to the corners of a polygon-shaped movable micro-element (10).
16. The movable micro-element according to any one of claim 13 or 14, wherein said flexure hinges (70) are attached to the sides of a polygon-shaped movable micro-element (10).
17. The movable micro-element (10) according to any one of claim 10-16, wherein at least one of said flexure hinges (70) and/or at least one of said torsional axis is meander shaped.
18. The movable micro-element (10) according to any one of claim 1-17, wherein said surface (20) further comprising a counter electrode (30) laterally spaced apart from said address electrode (40) where said address electrode (40) and

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said counter electrode (30) are capable to electrostatically attract said micro-element (10).

19. The movable micro-element (10) according to claim 18,  
wherein said predetermined pulsed signal is capable to clear  
out a potential difference between said address electrode  
(40) and said counter electrode (30) and thereby restoring  
said movable micro-element (10) to said non addressed state.
20. The movable micro-element (10) according to claim 18,  
wherein said predetermined pulsed signal is capable to clear  
out a potential difference between said address electrode  
(40) and said counter electrode (30) and thereby restoring  
said movable element (10) to an electrostatically  
unattracted state.
21. The movable micro-element (10) according to claim 19-20,  
wherein said predetermined pulsed signal is electromagnetic  
radiation directed onto said movable element (10).
22. The movable micro-element (10) according to claim 19-20,  
wherein said predetermined pulsed signal is an electric  
signal capable of discharging a capacitor connected to said  
address electrode (40) and loaded with said first potential.
23. The movable micro-element (10) according to claim 1 or  
19, wherein said predetermined pulsed signal is synchronized  
with said time period  $\Delta t + \Delta t'$  so that the time  $\Delta t'$  is  
essentially equal to the pulse length of said predetermined  
pulsed signal.
24. A spatial light modulator having a plurality of  
reflecting elements, characterized in that said reflecting  
elements are movable micro-elements (10) according to any  
one of claims 1-23.
25. The spatial light modulator according to claim 24,  
wherein said reflecting elements are set to a potential via  
a common element pin.
26. The spatial light modulator according to claim 23 or 24,  
wherein said counter electrodes (30) are set to a potential  
via a common counter pin.

27. The spatial light modulator according to claim 23-26,  
wherein all reflecting elements are in an addressed state  
for essentially the same period of time.
28. An apparatus for patterning a workpiece (60) arranged at  
an image plane and sensitive to electromagnetic radiation,  
comprising:
- a source (11) emitting electromagnetic radiation  
directed onto an object plane,
  - a computer controlled reticle (30) comprising a  
plurality of reflecting elements, adapted to receive  
said electromagnetic radiation at said object plane  
and to relay said electromagnetic radiation toward  
said work piece (60) arranged at said image plane,  
where said computer controlled reticle (30) comprising  
a plurality of reflecting elements characterized in  
that said reflecting elements are movable micro-  
elements according to any one of claims 1-23.
29. A method of reducing an imprinting effect of a movable  
micro-element arranged spaced apart from a surface, where  
said surface comprises at least one electrode, comprising  
the actions of:
- setting said movable micro-element to a second  
potential defining a non addressed state,
  - addressing an address electrode to a first potential,  
where said address electrode is arranged on said  
surface and capable to electrostatically attract said  
movable micro-element,
  - switching said movable micro-element from said second  
potential to a third potential, defining an addressed  
state, at a time  $\Delta t$  before a predetermined pulsed  
signal is emitted,
  - keeping said movable micro-element in said addressed  
state for a time period  $\Delta t + \Delta t$ .

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30. The method according to claim 29, further comprising the action of:
- switching said micro-element from said third potential back to said second potential thereby returning to said non-addressed state.
- 5
31. The method according to claim 29, further comprising the action of:
- switching said movable micro-element into an electrostatically unattracted state after being in said addressed state.
- 10
32. The method according to claim 31, further comprising the action of:
- clearing out a potential difference between said address electrode and said movable micromirror by means of said predetermined pulsed signal and thereby restoring said movable element to said electrostatically unattracted state.
- 15
33. The method according to claim 29-32, wherein said predetermined pulsed signal is an electromagnetic radiation signal directed onto said movable micro-element.
- 20
34. The method according to claim 29-32, wherein said predetermined pulsed signal is an electric signal capable to initiate a discharging of a capacitor connected to said address electrode and loaded with said first potential.
- 25
35. The method according to any one of claim 29-34, wherein said time period  $\Delta t + \Delta t'$  is shorter than 10ms.
36. The method according to any one of claim 29-34, wherein said time period  $\Delta t + \Delta t'$  is shorter than 10 $\mu$ s.
37. The method according to any one of claim 29-36, wherein a value of said second potential is essentially equal to half a maximum potential addressed to said address electrode defining an undeflected state at both the maximum and a minimum potential addressed to said address electrode and
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said third potential is essentially equal to said minimum potential addressed to said address electrode.

38. The method according to any one of claim 29-37, further comprising the action of:

- 5 - supporting said movable micro-element along a mid section by a pair of torsion hinges defining a torsional axis.

39. The method according to any one of claim 29-37, further comprising the action of:

- 10 - supporting said movable micro-element along its mid section by a pair of pivot element defining a tilting axis and where said restoring element is at least one flexure hinge capable of restoring said movable micro-element in an undeflected state but at the same time permitting said movable micro-element to tilt around said tilting axis.

15 40. The method according to any one of claim 38-39, further comprising the action of:

- restoring said movable micro-element with at least one flexure hinge.

20 41. The method according to any one of claim 29-37, further comprising the action of:

- 25 - supporting said movable micro-element along one of its mid sections by a pair of flexure hinges which are capable of restoring said movable micro-element to a relaxed state but at the same time permitting said movable micro-element to make an orthogonal movement with respect to said surface comprising said at least one electrode.

42. The method according to any one of claim 29-37, further comprising the action of:

- 30 - supporting said movable micro-element along two mid sections by a pair of flexure hinges capable of restoring said movable micro-element to a relaxed state but at the same time permitting said movable micro-element to make an orthogonal movement with respect to said surface comprising said at least one electrode.
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43. The method according to any one of claim 41-42, wherein said flexure hinges are attached to the corners of a polygon.
44. The method according to any one of claim 41-42, wherein said flexure hinges are attached to the sides of a polygon.
45. The method according to any one of claim 38-44, wherein at least one of said flexure hinges and/or at least one of said torsional axis is meander shaped.
46. The method according to any one of claim 29-45, where said movable micro-element is a movable micro-element according to any one of claim 1-23.
47. The method according to any one of claim 29-46 further comprising the action of:
- synchronizing said predetermined pulsed signal with said time period  $\Delta t + \Delta t'$  so that the time  $\Delta t'$  is essentially equal to the pulse length of said predetermined signal.
48. The method according to claim 29, further comprising the action of:
- neutralizing cumulated imprinting effects while prohibiting said pulsed signal to reach said movable micro elements.
49. The method according to claim 48, wherein said neutralizing action is performed by deflecting individual movable micro element in a reverse direction compared to the way they are deflected during intended operation.
50. The method according to claim 49, wherein individual movable micro elements are deflected in a first direction a given time and a given degree of deflection depending on the cumulated time and degree of deflection in a second deflection direction.
51. The method according to claim 48, wherein said neutralizing of said cumulated imprinting effects are performed between different strips building up a complete pattern on a workpiece.

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52. The method according to claim 48, wherein said neutralizing of said cumulated imprinting effects is performed after at least one movable micro element has been deflected a predetermined cumulated time period.

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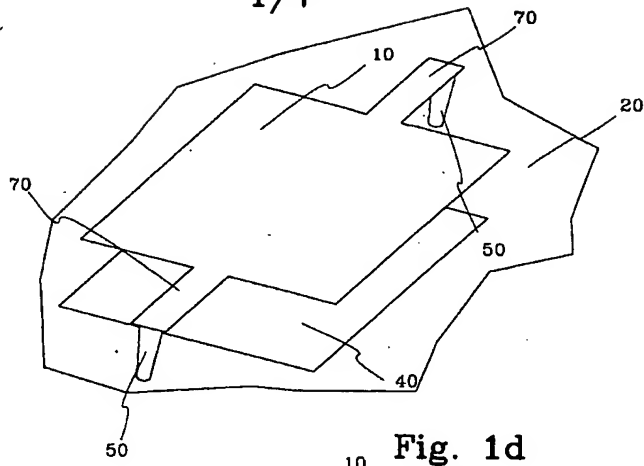


Fig. 1d

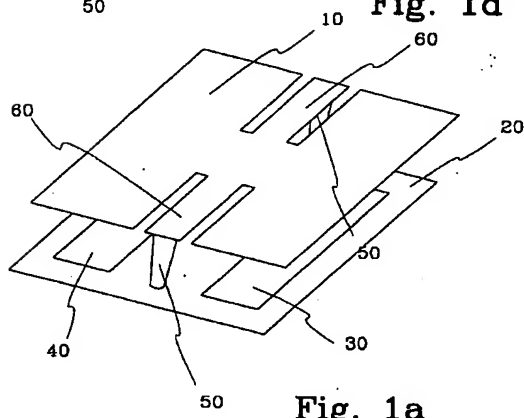


Fig. 1a

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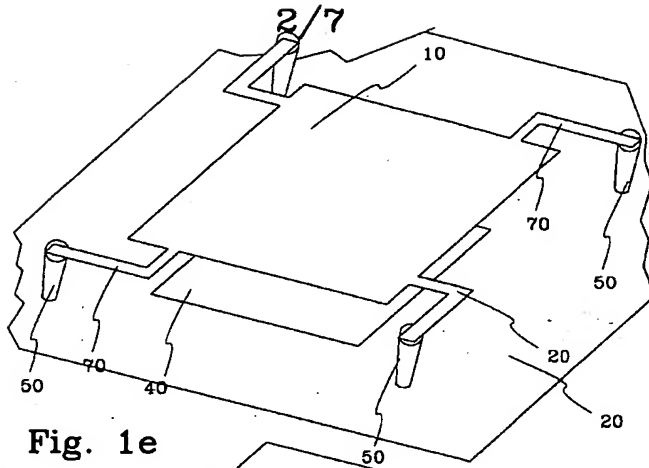


Fig. 1e

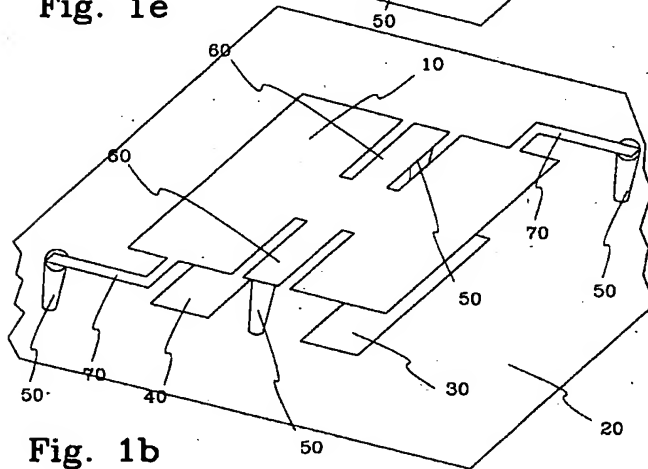


Fig. 1b

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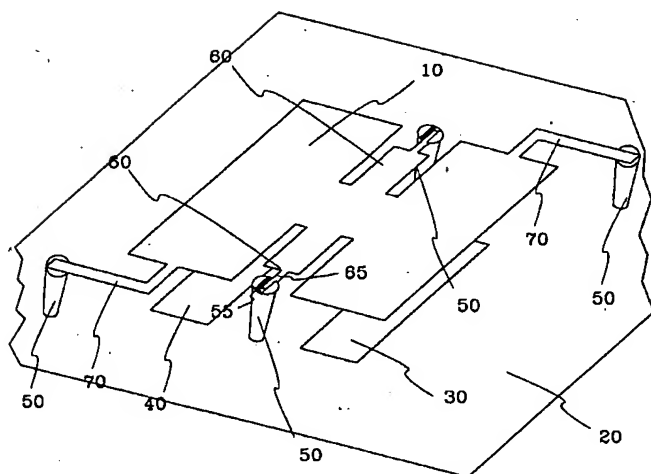


Fig. 1c

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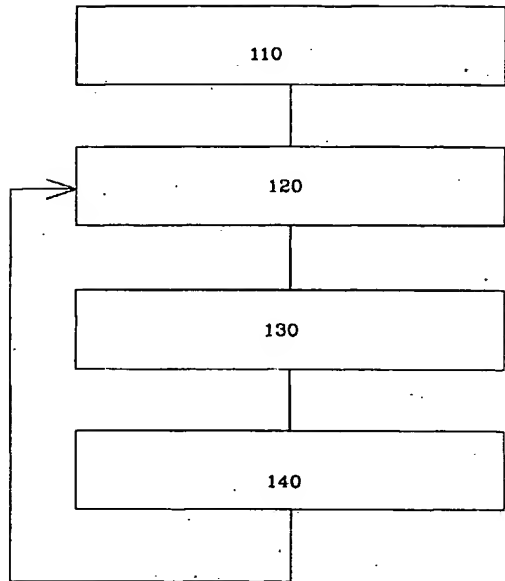


Fig. 2

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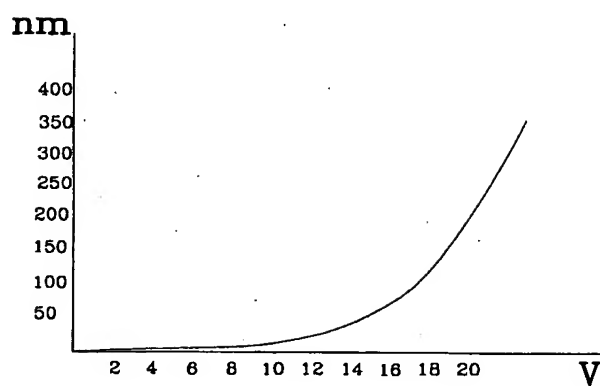


Fig. 3

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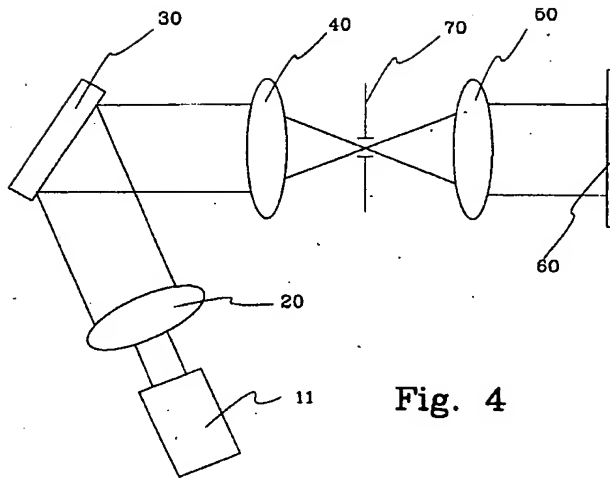


Fig. 4

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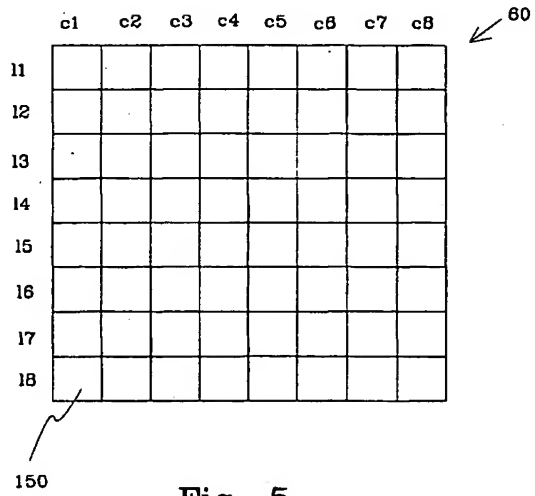


Fig. 5

## 【手続補正書】

【提出日】平成15年8月4日(2003.8.4)

## 【手続補正1】

【補正対象書類名】特許請求の範囲

【補正対象項目名】全文

【補正方法】変更

【補正の内容】

【特許請求の範囲】

【請求項1】

少なくとも1つの電極を有する表面(20)から離間して配置されて、履歴効果の少ない、可動マイクロ素子(10)であって、前記可動マイクロ素子(10)には、少なくとも1つの復帰部材(60, 70)が接続され、前記表面(20)上にはアドレス電極(40)が配設され、前記可動マイクロ素子(10)を静電吸引可能であり、前記アドレス電極(40)が、第1電位にアドレスされるものにおいて、

前記可動マイクロ素子(10)は、先ず、所定のパルス信号が前記可動マイクロ素子(10)に対して発信される前の時間 $\Delta t$ において、非アドレス状態を形成する第2電位に設定され、前記可動部材は、前記第2電位から、アドレス状態を形成する第3電位に切り替えられ、前記履歴作用は、前記可動マイクロ素子(10)のアドレス状態デューティサイクルを減少させることによって低減される可動マイクロ素子(10)。

【請求項2】

請求項1の可動マイクロ素子(10)であって、前記可動マイクロ素子(10)は、前記第3電位を前記第2電位へ戻すことによって、前記アドレス状態後に、前記非アドレス状態に戻される可動マイクロ素子(10)。

【請求項3】

請求項1の可動マイクロ素子(10)であって、前記可動マイクロ素子(10)は、前記第2電位状態後に、静電非吸引状態に切り替えられる可動マイクロ素子(10)。

【請求項4】

請求項3の可動マイクロ素子(10)であって、前記所定パルス信号は、前記アドレス電極(40)と、前記可動マイクロ素子(10)との間の電位差をクリア可能であり、これにより、前記可動マイクロ素子(10)を前記静電非吸引状態に復帰させる可動マイクロ素子(10)。

【請求項5】

請求項1又は4の可動マイクロ素子(10)であって、前記所定パルス信号は、前記可動マイクロ素子(10)に向けられる電磁放射である可動マイクロ素子(10)。

【請求項6】

請求項1又は4の可動マイクロ素子(10)であって、前記所定パルス信号は、前記アドレス電極(40)に接続されるとともに、前記第1電位をローディングされるコンデンサの放電を開始させることが可能な電気信号である可動マイクロ素子(10)。

【請求項7】

請求項1の可動マイクロ素子(10)であって、前記可動マイクロ素子は、 $10\text{ms}$ よりも短い時間 $\Delta t + \Delta t'$ 、前記アドレス状態に維持される可動マイクロ素子(10)。

【請求項8】

請求項1の可動マイクロ素子(10)であって、前記可動マイクロ素子は、 $10\mu\text{s}$ よりも短い時間 $\Delta t + \Delta t'$ 、前記アドレス状態に維持される可動マイクロ素子(10)。

【請求項9】

請求項1の可動マイクロ素子(10)であって、前記第2電位の値は、前記アドレス電極(40)に対してアドレスされる最大電位と最小電位との両方において非偏向状態を形成する、前記アドレス電極(40)に対してアドレスされる最大電位の半分に実質的に等しく、前記第3電位は、前記アドレス電極(40)に対してアドレスされる前記最小電位に実質的に等しい可動マイクロ素子(10)。

## 【請求項 10】

請求項 1～9 のいずれかの可動マイクロ素子 (10) であって、前記可動マイクロ素子 (10) は、その中間部分に沿って、捻れ軸心を形成する一对の捻りヒンジ (60) によって支持されている可動マイクロ素子 (10)。

## 【請求項 11】

請求項 1～9 のいずれかの可動マイクロ素子 (10) であって、前記可動マイクロ素子 (10) は、その中間部分に沿って、傾動軸心を形成する一对の回動部材 (65) によって支持され、前記復帰部材は、非偏向状態において前記可動マイクロ素子 (10) を復帰させるとともに、これと同時に、前記可動マイクロ素子 (10) が前記傾動軸心回りで傾動することを許容することが可能な少なくとも 1 つの屈曲ヒンジ (70) である可動マイクロ素子 (10)。

## 【請求項 12】

請求項 10 の可動マイクロ素子 (10) であって、更に、非偏向状態において前記可動マイクロ素子を復帰させるとともに、これと同時に、前記可動マイクロ素子 (10) が前記傾動軸心または前記捻れ軸心回りで傾動することを許容することが可能な少なくとも 1 つの屈曲ヒンジを有する可動マイクロ素子 (10)。

## 【請求項 13】

請求項 1～9 のいずれかの可動マイクロ素子 (10) であって、前記可動マイクロ素子 (10) は、その中間部分の 1 つに沿って、前記可動マイクロ素子 (10) を弛緩状態へ復帰させるとともに、これと同時に、前記可動マイクロ素子 (10) が前記少なくとも 1 つの電極を有する前記表面 (20) に対して垂直移動することを許容することが可能な一对の屈曲ヒンジ (70) によって支持されている可動マイクロ素子 (10)。

## 【請求項 14】

請求項 1～9 のいずれかの可動マイクロ素子 (10) であって、前記可動マイクロ素子 (10) は、その中間部分の二つに沿って、前記可動マイクロ素子 (10) を弛緩状態に復帰させるとともに、これと同時に、前記可動マイクロ素子 (10) が、前記少なくとも 1 つの電極を有する前記表面 (20) に対して垂直移動することを許容することが可能な二対の屈曲ヒンジ (70) によって支持されている可動マイクロ素子 (10)。

## 【請求項 15】

請求項 13 又は 14 のいずれかの可動マイクロ素子 (10) であって、前記屈曲ヒンジ (70) は、多角形状の可動マイクロ素子 (10) の角部に取り付けられている可動マイクロ素子 (10)。

## 【請求項 16】

請求項 13 又は 14 のいずれかの可動マイクロ素子 (10) であって、前記屈曲ヒンジ (70) は、多角形状の可動マイクロ素子 (10) の面部に取り付けられている可動マイクロ素子 (10)。

## 【請求項 17】

請求項 10～16 のいずれかの可動マイクロ素子 (10) であって、前記屈曲ヒンジ (70) の少なくとも 1 つおよび／又は前記捻れ軸心の少なくとも 1 つは、曲折形状である可動マイクロ素子 (10)。

## 【請求項 18】

請求項 1～17 のいずれかの可動マイクロ素子 (10) であって、前記表面 (20) は、更に、前記アドレス電極 (40) から側方に離間した対向電極 (30) を有し、前記アドレス電極 (40) と前記対向電極 (30) とは、前記可動マイクロ素子 (10) を静電吸引可能である可動マイクロ素子 (10)。

## 【請求項 19】

請求項 18 の可動マイクロ素子 (10) であって、前記所定パルス信号は、前記アドレス電極 (40) と前記対向電極 (30) との間の電位差をクリア可能であり、これによって、前記可動マイクロ素子 (10) を前記非アドレス状態へ復帰させる可動マイクロ素子 (10)。

## 【請求項 20】

請求項 18 の可動マイクロ素子 (10) であって、前記所定パルス信号は、前記アドレス電極 (40) と前記対向電極 (30) との間の電位差をクリア可能であり、これによって、前記可動マイクロ素子 (10) を静電非吸引状態へ復帰させる可動マイクロ素子 (10)。

## 【請求項 21】

請求項 19～20 の可動マイクロ素子 (10) であって、前記所定パルス信号は、前記可動マイクロ素子 (10) に向けられる電磁放射である可動マイクロ素子 (10)。

## 【請求項 22】

請求項 19～20 の可動マイクロ素子 (10) であって、前記所定パルス信号は、前記アドレス電極 (40) に接続されるとともに、前記第 1 電位をローディングされるコンデンサの放電をすることが可能な電気信号である可動マイクロ素子 (10)。

## 【請求項 23】

請求項 7 又は 8 の可動マイクロ素子 (10) であって、前記所定パルス信号は、前記時間  $\Delta t'$  が、前記所定信号のパルス長と実質的に等しくなるように、前記時間  $\Delta t + \Delta t'$  と同期される可動マイクロ素子 (10)。

## 【請求項 24】

複数の反射部材を備える空間光変調器であって、前記反射部材が、請求項 1～23 のいずれかの可動マイクロ素子 (10) であることを特徴とする空間光変調器。

## 【請求項 25】

請求項 24 の空間光変調器であって、前記反射部材は、1 つの共通の素子ピンを介して 1 つの電位に設定される空間光変調器。

## 【請求項 26】

請求項 23 又は 24 の空間光変調器であって、前記対向電極 (30) は、1 つの共通の対向ピンを介して 1 つの電位に設定される空間光変調器。

## 【請求項 27】

請求項 23～26 の空間光変調器であって、前記反射部材は、すべて、実質的に同じ時間、アドレス状態にされる空間光変調器。

## 【請求項 28】

結像面に配置され、電磁放射に感応する加工物 (60) をパターニングするための装置であって、以下、

対物面に向けて電磁放射を放出するソース (11) と、

前記対物面において前記電磁放射を受け、この電磁放射を前記結像面に配置された前記加工物 (60) に向けて中継するように構成された、複数の反射素子を有するコンピュータ制御焦点板 (30) とを有し、

ここで、前記コンピュータ制御焦点板 (30) が複数の反射部材を有するものにおいて、前記反射部材は、請求項 1～23 のいずれかの可動マイクロ素子であることを特徴とする装置。

## 【請求項 29】

表面から離間して配置された可動マイクロ素子の履歴効果を低減させるための方法であって、ここで前記表面が、少なくとも 1 つの電極を有するものにおいて、前記方法は以下の工程：

前記可動マイクロ素子を、非アドレス状態を形成する第 2 電位に設定する工程と、

アドレス電極を第 1 電位にアドレスする工程であって、ここでアドレス電極は、前記表面上に配置され、前記可動マイクロ素子を静電吸引可能である工程と、

前記可動マイクロ素子を、所定のパルス信号が発信される前の時間  $\Delta t$  において、前記第 2 電位から、アドレス状態を形成する第 3 電位に切り替える工程と、

前記可動マイクロ素子のアドレス状態デューティサイクルを減少させることによって前記履歴作用を減少させる工程と

を包含する方法。

## 【請求項 30】

請求項 29 の方法であって、更に、以下の工程：

前記第 3 電位から前記第 2 電位へ前記可動マイクロ素子を切り替えることによって、前記非アドレス状態に戻す工程を包含する方法。

## 【請求項 31】

請求項 29 の方法であって、更に以下の工程：

前記可動マイクロ素子を、前記アドレス状態後に、静電非吸引状態に切り替える工程を包含する方法。

## 【請求項 32】

請求項 31 の方法であって、更に以下の工程：

前記所定パルス信号によって、前記アドレス電極と、前記可動マイクロミラーとの間の電位差をクリアし、これにより、前記可動マイクロ素子を前記静電非吸引状態に復帰させる工程を包含する方法。

## 【請求項 33】

請求項 29～32 のいずれかの方法であって、前記所定パルス信号は、前記可動マイクロ素子に向けられる電磁放射信号である方法。

## 【請求項 34】

請求項 29～32 のいずれかの方法であって、前記所定パルス信号は、前記アドレス電極に接続されるとともに、前記第 1 電位をローディングされるコンデンサの放電を開始させることが可能な電気信号である方法。

## 【請求項 35】

請求項 29～34 のいずれかの方法であって、前記可動マイクロ素子は、10 ms よりも短い時間  $\Delta t + \Delta t'$ 、前記アドレス状態に維持される方法。

## 【請求項 36】

請求項 29～34 のいずれかの方法であって、前記可動マイクロ素子は、10  $\mu$ s よりも短い時間  $\Delta t + \Delta t'$ 、前記アドレス状態に維持される方法。

## 【請求項 37】

請求項 29～36 のいずれかの方法であって、前記第 2 電位の値は、前記アドレス電極に対してアドレスされる最大電位と最小電位との両方において非偏向状態を形成する、前記アドレス電極に対してアドレスされる最大電位の半分に実質的に等しく、前記第 3 電位は、前記アドレス電極に対してアドレスされる前記最小電位に実質的に等しい方法。

## 【請求項 38】

請求項 29～37 のいずれかの方法であって、更に以下の工程：

前記可動マイクロ素子を、その中間部分に沿って、捻れ軸心を形成する一対の捻りヒンジによって支持する工程を包含する方法。

## 【請求項 39】

請求項 29～37 のいずれかの方法であって、更に以下の工程：

前記可動マイクロ素子を、その中間部分に沿って、傾動軸心を形成する一対の回動部材によって支持する工程であって、ここで、前記復帰部材は、非偏向状態において前記可動マイクロ素子を復帰させるとともに、これと同時に、前記可動マイクロ素子が前記傾動軸心回りで傾動することを許容することが可能な少なくとも 1 つの屈曲ヒンジである工程を包含する方法。

## 【請求項 40】

請求項 38～39 のいずれかの方法であって、更に、以下の工程：

少なくとも 1 つの屈曲ヒンジによって前記可動マイクロ素子を復帰させる工程を包含する方法。

## 【請求項 41】

請求項 29～37 のいずれかの方法であって、更に、以下の工程：

前記可動マイクロ素子を、その中間部分の 1 つに沿って、前記可動マイクロ素子を弛緩状態に復帰させるとともに、これと同時に、前記可動マイクロ素子が前記少なくとも 1 つの

電極を有する前記表面に対して垂直移動することを許容することが可能な一対の屈曲ヒンジによって支持する工程を包含する方法。

【請求項 4 2】

請求項 2 9 ～ 3 7 のいずれかの方法であって、更に、以下の工程：

前記可動マイクロ素子を、その中間部分の二つに沿って、前記可動マイクロ素子を弛緩状態に復帰させるとともに、これと同時に、前記可動マイクロ素子が、前記少なくとも 1 つの電極を有する前記表面に対して垂直移動することを許容することが可能な一対の屈曲ヒンジによって支持する工程を包含する方法。

【請求項 4 3】

請求項 4 1 ～ 4 2 のいずれかの方法であって、前記屈曲ヒンジは、多角形の角部に取り付けられている方法。

【請求項 4 4】

請求項 4 1 ～ 4 2 のいずれかの方法であって、前記屈曲ヒンジは、多角形の面部に取り付けられている方法。

【請求項 4 5】

請求項 3 8 ～ 4 4 のいずれかの方法であって、前記屈曲ヒンジの少なくとも 1 つおよび／又は前記捻れ軸心の少なくとも 1 つは、曲折形状である方法。

【請求項 4 6】

請求項 2 9 ～ 4 5 のいずれかの方法であって、前記可動マイクロ素子は、請求項 1 ～ 2 3 のいずれかの可動マイクロ素子である方法。

【請求項 4 7】

請求項 3 5 又は 3 6 のいずれかの方法であって、更に、以下の工程：

前記所定パルス信号を、前記時間  $\Delta t'$  が、前記所定信号のパルス長と実質的に等しくなるように、前記時間  $\Delta t + \Delta t'$  と同期させる工程を包含する方法。

【請求項 4 8】

請求項 2 9 の方法であって、更に、以下の工程：

前記パルス信号が前記可動マイクロ素子に到達することを阻止しながら累積履歴作用を中和化する工程を包含する方法。

【請求項 4 9】

請求項 4 8 の方法であって、前記中和化工程は、前記可動マイクロ素子が意図された作動中に偏向される状態に対してこれら個々の可動マイクロ素子を逆方向に偏向させることによって行われる方法。

【請求項 5 0】

請求項 4 9 の方法であって、個々の可動マイクロ素子は、前記累積時間及び第 2 偏向方向に於ける偏向の度合いに応じて、所与の時間及び所与の変更度、第 1 方向に偏向される方法。

【請求項 5 1】

請求項 4 8 の方法であって、前記累積履歴作用の前記中和化は、加工物上の完全なパターンを構成する異なるストリップ間において行われる方法。

【請求項 5 2】

請求項 4 8 の方法であって、前記累積履歴作用の前記中和化は、少なくとも 1 つの可動マイクロ素子が所定の累積時間偏向された後に行われる方法。

## 【国際調査報告】

1 INTERNATIONAL SEARCH REPORT		International application No. PCT/SE 02/00142
A. CLASSIFICATION OF SUBJECT MATTER		
IPC7: 602B 26/08, B81B 3/00 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC7: 602B, B81B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE, DK, FI, NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EPO-INTERNAL		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
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Y	---	4-6, 10-22, 32-34, 38-45
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<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reasons (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principles or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is considered with one or more other such documents, each contribution being obvious to a person skilled in the art "Z" document number of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
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2 INTERNATIONAL SEARCH REPORT		International application No. PCT/SE 02/00142
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